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NEMATODES AND AGRICULTURE.

If the roots of practically any species of plants, freshly plucked from the soil, are shaken up with a little water and if that water is examined with a hand-lens, quantities of organisms will be seen whipping themselves with rapid contortions of the whole body. When killed by heat, they are seen to be more or less cylindrical, unsegmented, without conspicuous organs of locomotion and more or less transparent; all are small, the length of the largest being about a centimeter. They are members of a group of animals called nematodes, comparable in number and importance with the insects, and they are found in every type of environment where animals can exist, in inconceivable abundance. They are common in salt-water, and in the ooze from the bottom of the sea they are found in thousands. They are abundant in the sands of the sea-shore and the numbers found in the ordinary arable soil amount to thousands of millions per acre. They have been found in deserts, at the bottom of lakes and rivers, in hot-springs and in polar ice. About half of the known species are parasitic, but this is probably an unfair method of calculation as most of the free-living ones are unknown. Practically all species of vertebrates harbour some species of nematodes. Adults or larvae are found in every group of invertebrates. Most domestic plants can be attacked. Economically, it is estimated that one species, the gall eelworm, is one of the worst pests known to agriculture; the annual losses by it to the world are measured in hundreds of millions of dollars. The Bureau of Animal Industry of the United States estimates that the live-stock losses there caused by the attacks of nematodes are, at least, one hundred million dollars per year. Sixty per cent. of human beings harbour hookworms and ascarids—to mention only the commonest of the large number of nematode parasites attacking man.

It is the more surprising, therefore, how little of that which is known finds its way correctly into text-books. The average biologist's conception of a nematode is based on *Ascaris* and *Trichinella*, both aberrant parasitic forms, degenerate in morphology and specialized in life history. It is no wonder therefore, that a worker in applied biology knows so little about the group. It is largely the fault of his teachers and of his text-books, because the information on which a correct conception of nematodes could be based, is readily available, and experimental material for the teaching of both morphology and bionomics exists at everyone's door.

But it is in connection with disease in man and domesticated animals, that the group has been most intensively studied, although research on the animal species is very recent indeed. We now know, however, that herbivorous animals suffer almost universally from nematode parasites, all of which must pass part of their life-cycle outside of the animal's body. In many cases this is passed on the pasture and ingress to the body is the result of eating the nematode larva with the grass. It has been claimed as a virtue and sign of good plant husbandry to succeed in growing two blades of grass where before only one grew. Unfortunately, so far as these nematode parasites are concerned, it is a vice; and success in this form of agriculture is the main reason for heavy parasitism among the animals which feed on it. The reason for this paradox is obvious when we consider the simple facts concerned with the multiplication of parasites and their relationship to disease.

Disease is mainly due to the numbers of worms harboured. All animals carry worms, more or less, in the free state but usually only in small numbers. It is only when these increase to a great extent that the body suffers. Now these nematodes, successful parasites as they are, cannot multiply inside the body. One egg or one larva entering the body can only become one adult. The eggs and larvae of this one adult must escape on to the pasture and be swallowed again before they too can become adults. In Nature, these eggs passed in the droppings over a wide area, only occasionally were swallowed and so in the early stages of evolution, the female nematodes learned to lay large numbers of eggs to ensure the survival of the race. Man now interfered with the balance of Nature and concentrated his animals on a small area. The eggs also were concentrated and infection of his animals accrued on an enormously increased scale. Parasitic disease was the result and the losses now-a-days are enormous. This is directly due to the success of the botanist and soil chemist in their own fields: as their efforts to improve conditions continue to succeed, the damage to animals will continue to increase.

The possible control of these worms both in the animal shed and the field has recently been the subject of investigation at the Institute of Parasitology—an institute recently established jointly by the Empire Marketing Board and the National Research Council at Macdonald College, McGill University, and we publish in this issue an article detailing the results so far obtained. These are sufficiently encouraging to suggest that means of overcoming this state of affairs may actually be within sight, and that one of the worst enemies of the stock-owner may ultimately be controlled by simple, inexpensive methods of treating manure, the fertilizing value of which may be sufficiently increased to cover the cost of the treatment.

Nematodes are, however, not invariably harmful. Many of the forms parasitic in man and animals appear to be harmless commensals while some of the free-living forms are actually beneficial. One species of nematode at least is known to attack pathogenic nematodes and there may be many more. This particular species was first found feeding on a form injurious to the roots of citrus trees. It moves actively among the soil near the roots, swallowing the other nematodes alive and whole. Other forms are known to prey on free-living forms—one with jaws heavily armed with rows of backward pointed teeth has been appropriately named the "Shark" nematode —*Selachinema*.

Nematodes parasitic in harmful insects may be of considerable benefit to agriculture and many examples of this have been recorded. Cobb and his colleagues showed that a species of *Mermis* was an important factor in the birth rate of grasshoppers in America. Related species are found in Hemiptera—including one in the sugar-cane froghopper. Goodey found that the frit-fly of oats in England was parasitized by a nematode which generally resulted in sterilization of both sexes. Many of the Coleoptera are infected by nematodes and Cobb reports that these worms play an important part in the control of cucumber beetles; Glaser finds that a nematode may be of importance in the control of the Japanese beetle, while Oldham records a heavy parasitism in *Scolytus* elm bark beetles which often causes sterility.

The biological control of insect pests is now a well established branch of applied science. It is obvious that we have just commenced the study of this important subject and it is obvious that a closer study of the nematodes as control agents will be of great value. In time this interesting group of animals may partly repay agriculture for the losses they cause in other directions.

T. W. M. C.

COCOA IN 1934.

There was an improvement in the price of cocoa in 1934. The development of production and consumption is shown in the following extract from the *Gordian*, XL, No. 950:—

When basing the calculations on the quantities of cocoa actually harvested in 1934 there remains a surplus of about 10,000 to 15,000 tons. Yet, compared with 1933 and taking into consideration the large yields of the 1934 main crop, this surplus is very small. It almost seems that consumption is gradually reaching the volume of the crops.

World Production, Consumption and Stocks of Cocoa.—(In tons).

	Crop.	Consumption.	Surplus.	Increase of Stocks since Dec., 1926.
1927 ..	499,000	452,000	+47,000	47,000
1928 ..	529,000	499,000	+30,000	77,000
1929 ..	522,000	516,000	+ 6,000	83,000
1930 ..	510,000	508,000	+ 2,000	85,000
1931 ..	529,000	540,000	−11,000	74,000
1932 ..	577,000	515,000	+62,000	136,000
1933 ..	577,000	535,000	+42,000	178,000
1934 .	595,000	583,000	+12,000	190,000

ON THE CONTROL OF THE FREE-LIVING LARVAE OF BURSATE NEMATODES OF DOMESTIC ANIMALS.

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In the tropics and sub-tropics hookworm disease is one of the most serious affecting man: from the tropics to within the Arctic circle hookworms of various species cause a high mortality in dogs, cats, foxes and other carnivores. In more temperate climates the farmers' most universal and financially serious losses are caused by related species which inhabit the stomach and intestines of domestic animals.

The three families of bursate nematodes which affect domestic stock—the Trichostrongylidae, the Ancylostomidae (which includes the hookworms) and the Strongylidae—all have similar simple life histories, but the larvae vary in their resistance to unfavourable conditions, such as drought and cold. Undoubtedly the most resistant are those of the horse Sclerostomes—especially the genus *Strongylus*—whose larvae, owing to the physical and chemical composition of horse faeces, develop more easily than in the faeces of carnivorous animals. Thus, conditions which are lethal to Sclerostome larvae in horse faeces should also be lethal to larvae in other faeces.

Worm parasites cannot multiply within the body. One infective stage entering the body can only become a single adult. Their eggs or larvae must, in all cases, spend some time outside the body before re-entering, and a heavy infection, therefore, must depend on a large number of these infective forms being swallowed or penetrating the skin of the host. These parasites lay minute eggs which pass from the host in the droppings where they embryonate and hatch. The small larvae which emerge, feed and moult and feed again on the bacteria in the droppings or on the adjacent ground. It is not until they have moulted twice, however, that they are capable of infecting the same or another host. The second moult takes place in about four to five days in hot weather, and a correspondingly longer time in cool weather. Once this infective stage has been reached, the larvae cease to feed, become very resistant to adverse influences and do not develop further until the host is entered. After a more or less complicated migration in the host, they develop to sexual maturity and it is during this part of their life cycle that they do the greatest damage.

While it is possible to destroy effectively the adult worms within the host it is impossible to destroy the migrating forms. Accordingly to minimize the damage which these parasites do, it is necessary to attack the worm during its free-living stages. As we have seen, these consist of the eggs, the free-feeding larvae and the infective larvae. The eggs, *before* embryonation, are very resistant. The hatching eggs, and the free-feeding larval stages are, however, much less resistant and are more easily killed. The infective larvae, on the other hand, are again extremely resistant.

Infections may be caused by larvae which develop in faeces passed while animals are at pasture, in manure from stables or in small quantities of faeces which are not removed from the stable or pens. All three conditions present different problems of control.

Control of Larvae in Manure.

When faeces are passed in a stable and subsequently removed to a manure heap, they may be sterilized, as Schwartz has shown, by heating in a specially constructed box. Unfortunately, this entails some extra labour. Alternatively, chemicals may be used and although their use entails extra labour and the cost of purchase or production, much of the expense may be recovered in the extra fertilizing value of the manure.

Undoubtedly, one of the most effective methods of treating manure is with urine; that of cattle is as effective as that of horses, stale urine as fresh. Furthermore, a dilution of 25 per cent. water does not remove this lethal action. Even when diluted with an equal quantity of water, provided the droppings are thoroughly moistened before the eggs hatch, and the faeces remain moistened with the fluid for some days, larval development is prevented. Undiluted urine is lethal to free-feeding and infective larvae in 24 hours.

Urine can most easily and effectively be applied to manure if the latter is in a concrete pit. The ideal method is to have a double pit five feet deep and nine feet wide, or a singly pit up to 18 feet wide (where carts could be loaded from both sides), with the top projecting two feet above ground level. A cart standing at the side can then be filled easily by hand, even when only a little manure is left in the pit. In addition, a catch pit, with a pump, is desirable to collect the urine. When a double pit or two pits are used, one can be filled while the other is being treated; the same urine can be used to treat manure more than once.

If a pit is not available, manure can be treated while in a well-built heap, but this method is not so dependable. It is necessary in such a case to pour urine on the heap until the whole is soaked and to repeat this process two, three or even more times round the sides, especially if the heap is not packed sufficiently tightly to retain moisture. In a well-made heap it will be found that the larvae on the top of the centre are killed at the first application, but not those on the sides—especially at the corners—since the urine dries there too quickly.

On some farms urine is not readily available—especially where housed sheep are the main source of manure—or where the farm drainage is defective. In such cases, the manure may be sterilized against nematode larvae and its fertilizing value improved by the use of artificial

fertilizers. It is possible to apply these dry without the use of an elaborate pit, but this is another method with which mistakes would be easy and would entail most efficient mixing. A preferable alternative with artificial fertilizers which readily go into solution, is to apply them in the way recommended for urine.

Using cultures made of 40 grams of horse faeces, it has been possible to compare the relative lethal strengths of fertilizers in the presence of faeces. As some of the fertilizers rapidly lose their lethal action when in contact with faeces, it has been necessary to test this on eggs and larvae actually in faeces instead of isolated *in vitro*. The most effective artificial fertilizer is Urea—a fertilizer containing about 46 per cent. of nitrogen and the most concentrated of the nitrogenous group. It is lethal in as small a percentage as 0.9 per cent. both dry or in solution, to the free-living stages of Sclerostomes, when mixed before the eggs have hatched and left in the faeces until the larvae would normally have reached the infective stages. When used in a solution of only 1:24 to cover faeces after the larvae have reached the infective stage it destroys them all in 48 hours, many being killed in 24 hours.

Calurea, which contains about 35 per cent. nitrogen, is also efficient, but it needs to be used in the proportion of 1:80 of faeces by weight.

The other commoner nitrogenous artificial fertilizers which have been tested are Cyanamid, Calnitro, Calcium-nitrate, Nitro-chalk, Sodium-nitrate, Ammonium sulphate and Diammonium phosphate. Of these Cyanamid is probably the most powerful, but it is also the least pleasant to use in a dry state, and would be extremely difficult to use in water, as also would be Nitro-chalk.

Using Cyanamid, about four times the quantity would be necessary compared with Urea. Diammonium phosphate could be used in only slightly higher proportions. Sodium-nitrate and Ammonium sulphate are typical examples of fertilizers which are lethal *in vitro* to the free-living stages of Sclerostomes but which, in the presence of horse faeces, lose this action.

Non-nitrogenous Fertilizers.

Under some conditions of agriculture, a non-nitrogenous artificial fertiliser might be of greater value as a sterilizing agent than a nitrogenous fertilizer. Unfortunately, none as efficient as Urea or Calurea has yet been discovered. The best—a high-grade Kainit—approximates to Cyanamid, when mixed with the faeces before the eggs hatch and when it does not, quickly leach out. If the faeces cannot be treated until the larvae have reached the infective stage, Hydrated Lime is the most effective non-nitrogenous agent, 1:10 being completely effective in 48 hours and even 1:20 killing most of the larvae in 24 hours. Mixing Hydrated lime with faeces, however, causes the loss of some ammonia.

Carbonate of Potash and Muriate of Potash are almost of equal value; the former seems to have a somewhat more powerful action against the early free-living stage, the latter against the infective larvae. The presence of faeces rapidly decreases the lethal action of Muriate of Potash. Sulphate of Potash also has a lethal action but preliminary trials suggest that it is slower than the other potassic fertilizers.

Basic Slag and Superphosphate (containing 16 per cent. of phosphoric acid) have little, if any, lethal action. Superphosphate (containing 20 per cent. of phosphoric acid) when used in large quantities—about 1:8—does appear to reduce the number of live larvae.

Salt has frequently been recommended as a sterilizing agent against nematode larvae, but it has no fertilizing value, and therefore, none of its cost can be recovered in added crop returns. Its lethal action on Sclerostome eggs and larvae seems to be comparable to that of Kainit and the medium-strength nitrogenous manures. Used in combination with Urea, it adds little to the latter's action, except on infective sheep larvae present in somewhat dried sheep faeces.

Possible Application in Human Hookworm Areas.

In countries where hookworm is rife and night-soil plays an important rôle in the local schemes of agriculture, it will probably be found that Urea or Calurea can be used to sterilize the faeces with very little, if any loss, since night-soil is generally used for crops with a high nitrogen requirement. Much valuable work and money have been expended in finding methods for sterilizing and disposing of night-soil on land and in mine workings. For mines, salt is generally used. Although none of the cost of Urea or Calurea would be recovered as a fertilizing agent in a mine and in spite of their higher cost, their use may be found to be justified owing to their greater lethal potency.

In eastern Asia, in addition to urine, Ammonium sulphate, Chili nitrate and Lime are the chief substances of fertilizing value which have been recommended, even in as high a proportion as one of fertilizer to three of faeces. In Italy, the use of Cyanamid to sterilized night-soil applied to garden crops has been suggested.

A few other substances with a fertilizing value have been tested on the free-living stages of hookworms as well as many with no fertilizing value, some in large scale trials, others on small cultures of eggs or larvae *in vitro*. The importance of the problem is indicated by the wide range of chemicals tested. Among others, caustic soda, caustic potash, copper sulphate, sulphuric acid, ammonium carbonate, calcium hypochlorite, carbon disulphide, sodium bicarbonate, formalin, ammonia, carbolic acid and other gases dissolved in water, chloroform, pine oil, lysol, Eau de Javelle, phenosalyl, Fernback's liquor, potassium acetate, even hexylresorcinol, antiform, iodine, chlorine, bromine and silver nitrate have been tested, either to find methods of sterilizing faeces or to suggest methods which may be lethal to larvae at various stages in their development.

Slight differences in the lethal action may be expected in different samples of those fertilizers which occur as natural salts and in those fertilizers which are by-products of other industries and in

which impurities may therefore occur, but only in rare instances should the difference in composition of fertilizers be of practical importance.

Control of Grazing Areas.

Probably the most difficult parts of a farm on which to control nematode larvae are the grazing areas, whether permanent or temporary pastures, or fodder crops.

In extremely dry conditions Sclerostome larvae have been reported to live for years. In the laboratory, in water under conditions of heat and light suitable to stimulate them to activity, and, therefore, to use up their stored food granules, they will live for over a year. In Great Britain, it has been shown that some sheep nematode larvae will live for several months in the ground and withstand being ploughed in. Fortunately, other data suggest that given suitable weather conditions, steps can be taken to reduce the number of larvae which reach the infective stage. Leiper reports that the dry summer climatic conditions of 1934 in southern England were sufficiently severe to kill off 90 per cent. of sheep nematode larvae. Canadian summer climatic conditions on the Island of Montreal prevent the majority of Sclerostome larvae reaching the infective stage if the faeces are in thin layer, but if they are in a heap and shaded, or frequently moistened, most larvae reach the infective stage. Heavy rain flattening faeces undoubtedly contributes to the destruction of the free-feeding larvae, but whether it is because the faeces are more easily desiccated afterwards or not, has not yet been ascertained. Frequent use of a light harrow, by breaking up the faeces, will decrease the number of larvae which reach the infective stage, unless the weather is suitable for larval development. Harrowing after the larvae reach the infective stage may result in the death of some, and shorten the lives of others, but may also increase the danger by spreading more widely those which remain alive.

Urine, Urea, Sodium nitrate, Ammonium sulphate, Muriate of Potash, Salt and one per cent. and two per cent. Copper Sulphate solutions have been sprayed on faeces lying on grass, and the artificial fertilizers, including Hydrated lime, have been scattered as powders on horse faeces. The quantities tested so far have only been those which might be used when dressing pasture with a fertilizing agent, and in those quantities have not destroyed the larvae.

Calcium cyanide, used at the rate of 750 to 2,000 lb. per acre has been shown to decrease the incidence of *Heterodera radicicola*—a nematode parasitic on plants.

Control in Buildings.

The final source of infection—stables, stalls or pens—should be more easily treated—but they also present many difficulties owing to the great resistance of the infective larvae.

Sclerostome larvae in faeces will live over 16 weeks in 0.5 per cent. Permanganate of Potash and over nine weeks in two per cent. In 0.66 per cent. and one per cent. Lye, they will live over 11 weeks, in two per cent. they are all dead in just over a day and in three per cent. in just over an hour. In Lysol death occurs more quickly and in two per cent. Creolin they survive over seven hours. Sheep larvae have somewhat similar survival times, slightly shorter in some cases but longer in Lysol. Horse faeces containing unhatched eggs moistened with 1:10 to 1:100 dilutions of a commercial variety of Dakin's solution produced as many, if not more, infective larvae than faeces moistened with water; infective larvae lived for several months in one per cent. to ten per cent. dilutions.

In Germany, Milk of Lime has been suggested for use on stable walls.

Heat, either in the form of a naked flame or as steam, has been recommended for sterilizing animal quarters against helminths. A naked flame, while more mobile and therefore, more readily available, is unsuitable for most animal quarters owing to the danger of fire. Before a pen is sterilized with steam it should be washed as clean as possible since any faeces which may be left serve as a protection for larvae. For instance, steam at 20 lb. pressure from a half-inch jet takes over half-a-minute to sterilize completely 25 grams of *dried* horse faeces against Sclerostome larvae when held three to four inches away and the culture is three-quarters of an inch thick and four inches in diameter, although many larvae are killed in under half-a-minute; steam under similar pressure takes a somewhat similar time to sterilize 40 grams of *moist* faeces which being only about half-an-inch thick and three inches in diameter are more concentrated and therefore more exposed to a small jet, although containing more moisture to be heated. Steam at 20 lb. pressure has a temperature of 109°C. Even five grams of moist faeces retain infective larvae for over five seconds when flattened until about three-eighths of an inch thick and subject to a half-inch steam jet at 28 lb. pressure from three to four inches. Steam at 28 lb. has a temperature of 119°C.

Conclusions.

Urine and Urea provide the most successful method for sterilizing manure against the bursate nematode larvae which parasitize domesticated mammals.

The lethal action of many artificial fertilizers to the free-living stages decreases more or less rapidly in the presence of faeces.

Although the data presented deals with animal faeces, it is probable that Urea and Calurea may be of value in sterilizing human faeces where they are to be used as fertilizer.

At present there is no known practicable and completely efficient method of preventing infection on grazing lands.

Infective larvae are resistant to many disinfectants and therefore the use of unsuitable disinfectants may lead to a false sense of security.

Steam takes several seconds to kill larvae protected by small amounts of faeces.

THE ECOLOGICAL DISTRIBUTION OF SOME SOUTH AMERICAN FROG-HOPPERS OF THE GENIUS *TOMASPIS* (HEM., CERCOPIDAE).

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1. Introduction.

In the course of field-work on the biological control of West Indian insect pests, and more especially in the search for an effective natural enemy of the Trinidad sugar-cane froghopper (*Tomaspis saccharina*, Dist.), seventeen frog-hoppers of the genus *Tomaspis*, more or less closely related to *T. saccharina*, have been studied in the islands and on the mainland of South America, from Venezuela to the Amazon, and from the coast to the Apure River and Mount Roraima. Observations on the Antillean species have been published in the body of a general report (Myers, 1931). The ecology of *T. saccharina* is now being studied in great detail by Mr. A. Pickles, Entomologist to the Trinidad Sugar Cane Investigation Committee (*see* especially his valuable summary papers, 1933), who has also made an intensive investigation of *Tomaspis picklesi* C. and M., and to a less extent, of several other Lower Amazon forms. The data assembled in the present paper are in the nature of an ecological reconnaissance of fourteen mainland species, with a few notes on *T. saccharina* for comparison. A more comprehensive account of the plant-associations in the regions visited will be found in Myers (1933, 1934) and in a paper in course of preparation on the grass-associations of the Lower Amazon.

The greater part of the area is still covered by virgin vegetation, consisting, save for the Llanos of Venezuela and the Rio Branco-Rupununi savannahs, almost entirely of rain-forest. On the llanos, even on the wooded borders of their rivers, no froghoppers were found; so these great treeless plains may be omitted from the discussion. The rest of the region is dominated by forest, from which most of the cultivated areas which do exist, have been won. It is therefore, perhaps, not surprising that the majority of the fifteen froghoppers studied are, or apparently were originally, forest-dwellers, while only four seem restricted to savannah country. I have elsewhere (*e.g.*, Myers, 1932, p. 258) drawn attention to the curious fact that so many sugar-cane pests seem to have settled on that crop not from the primitive grasslands but from the forest, the tall canes apparently maintaining an environment which has more in common with forest conditions than with those of savannah.

There are at least four ways in which these fifteen froghopper species may be advantageously classified, namely, taxonomically, nutritionally, ethologically and ecologically (if Professor Wheeler will permit me a distinction, based on etymology, between "ethology" and "ecology"). Mr. China, in a paper now in the press, in collaboration with the present writer, has grouped them taxonomically on the basis of male genitalic structure, without, however, suggesting any generic or subgeneric standing for the segregates. The *saccharina* group includes *bodkini*, *propinqua*, *flavilatera* and a number of other species occurring outside our area. The *terrea* group comprises also *incompleta*, *morialis*, *rhynchosporae* and *picklesi*, while the *tristis* group includes that species and *mura*. *T. lineola*, *T. pubescens*, *T. radicis* and *T. rubra* are all unrelated to these segregates and show no affinity *inter se*.

On a nutritional* division, *T. saccharina*, *bodkini*, *propinqua*, *terrea*, *incompleta*, *morialis*, *picklesi*, *tristis*, *mura* and *pubescens* are grouped as grass-feeders. *Rhynchosporae* is apparently exclusively, and *flavilatera* largely, a sedge-feeder. The nymphs of *T. lineola*, *radicis* and *rubra*, on the other hand are almost invariably associated with *Dicotyledons*, chiefly woody or semi-woody ones. A form of *T. rubra* is an exception in that it attaches Aroids, especially *Philodendron*.

On an ethological basis we may divide them into those whose nymphs live at or near ground-level and have hatched from eggs laid in or near the soil, and those which lay their eggs towards the growing-point of the host-plant and generally frequent the tops as nymphs. To the first group belong *saccharina*, *pubescens*, *flavilatera*, *incompleta*, *picklesi*, *rubra*, *bodkini*, *propinqua*, *terrea*, *rhynchosporae*, *lineola*, and *radicis*. (eggs unknown in the last six). *T. tristis* and *morialis* form the second group, and probably also *mura*. Their habit of frequenting the tops of the plants, which must be regarded as foreign to *Tomaspis* behaviour is probably associated, in these riparian species, with variations (on the Amazon of very great amplitude) in the level of water.

The present paper is devoted to an ecological classification. It will become apparent that the different groupings do not coincide. We have, for instance, savannah forms from two of the main systematic groups; grass-feeding forms in all groups; sedge-feeders in two; while the forest species include many unrelated froghoppers.

Since woodland is the dominant plant-covering of the area, we may logically begin with the froghoppers of the virgin forest. These are connected with pure savannah forms by a beautiful ecological series, passing through species of second-growth shrubbery, of woodland clearings (natural and artificial) and of riparian grass communities.

2. Forest Froghoppers.

(*a*) *Froghoppers of virgin forest.*—*Tomaspis lineola*, *Fabr.*, occurs, never in great abundance, in mixed rain forest of various types over a wide

* Based on the food of the nymphs, since the adults are more eclectic.

stretch of country in Guiana and on the Lower Amazon (Pará). It seems equally at home in the truli palm (*Manicaria saccifera*) swamp-forest of the Orinoco Delta region, the mixed rain-forest of the Pakaraima Mountains, up to 2,000 feet, and many intervening mixed rain-forest communities. It has not been found in either type of Mora (*Mora* spp.) forest nor in the drier deciduous forest of the Pakaraima foothills. In mixed rain-forest in the North West District of British Guiana nymphs were found on a liane which scrambled over the surface of a prostrate rotten log.

Tomaspis radicis, C. and M. seems just as markedly confined to virgin rain-forest, and is distributed throughout British Guiana, in mixed rain-forest up to 2,700 feet in the Pakaraima Mountains. Unlike *T. lineola*, however, it occurs also in at least two types of rain-forest which are marked by the dominance of one tree-species, namely in mora forest (*Mora excelsa*) on the lowlands and in *Asheroa* forest at about 1,300 feet in the Pakaraima Mountains. On the Barima River spittle-masses of this froghopper were found on the ground, in lowlying riparian mora forest subject to flooding, with open undergrowth, and frequent bare clay patches largely occupied by land-crabs. It was not possible to trace the roots on which the nymphs were subsisting.

With regard to both these virgin forest species, in view of the ground-dwelling habits of their nymphs, it is interesting to remark the wide variation in the substratum of their various habitats, from the bare clay of lowlying mora forest and the almost equally bare peat and dead leaves of truli swamp, each with very scanty undergrowth, to the much more luxuriant ground-cover of the more elevated mixed rain-forests.

(*b.*) *Froghoppers of forest clearings.*—*Tomaspis rubra*, Linn., is frequent in suitable localities in Trinidad, Guiana and the Lower Amazon, and is, in fact, widespread over a great part of the mainland Neotropical Region. A form which lives on Aroids, especially climbers of the genus *Philodendron*, is found at times in virgin mixed rain-forest. It occurs near the summit of Mt. Tucuche, in Trinidad, at an elevation of slightly over 3,000 feet. At Santa Elena de Uairaen on the Venezuela-Brazil border, in the Pakaraima Mountains, I found it at a similar elevation; but in second-growth bordering a path through mixed rain-forest. Its more frequent habitat, however, is among the second-growth shrubs (*e.g.*, Piper spp. and Melastomes) of forest clearings, margins of paths and roadsides, abandoned cultivations, Indian provision-fields and the like. In such situations a common host, at least in Dutch and British Guiana, is a *Commelina* sp. Cacao fields frequently offer a very suitable habitat. In Trinidad Urich, Williams and others have recorded the Composite, *Eupatorium odoratum*, as a very frequent host. Whether the insects breeding on Aroids in the forest and in various quite unrelated plants in the clearings are different biological races or one eclectic form is a question which would well repay genetic and ecological investigation. There seem to be no constant structural nor even colour differences.

Tomaspis pubescens, Fabr.—Here is a very distinct, structurally isolated species which, although a regular grass-feeder, is restricted to forest communities. Among favourite host-plants are *Paspalum conjugatum* and *Panicum polygonatum*, which are essentially grasses of forest clearings, stream margins, and borders of paths and roads. They enter high forest wherever a large tree falls, or man makes a clearing. In the Orinoco Delta *T. pubescens* was especially frequent in the aboriginal Indian clearings, on the lateritic or sandy knolls which rise like islands from the swamp-forest. There, in the space round the Indian huts, were grassy patches growing *Paspalum conjugatum*, *Syntherisma digitata*, *Panicum pilosum* and an occasional small, narrow-leaved *Cyperus*. *T. pubescens* was found chiefly on the *Paspalum* and the small *Cyperus*. Native provision-fields, with *Paspalum conjugatum* as the chief host, form a preferred habitat throughout the mixed rain-forest and mora forest of Trinidad, the Guianas and the Lower Amazon, up to an elevation of 3,000 feet in the Pakaraima Mountains. In the Kanuku Mountains, under entirely virgin conditions, it was plentiful on *Hymenachne auriculata*, growing on the margin of a forest creek (the Napi). The dense beds of this grass, growing partly in water, and thus largely escaping the shade of the canopy (here supplied by natural second-growth on a frequently torrent-swept flood-plain), were the centre of the greatest insect activity, in marked contrast to the actual forest communities. Spiders and insects associated in large numbers with these beds included Attidae, Thomisidae, Gasteracanthidae, Lycosidae, Tettigoniidae, Acrididae, Gryllidae, Mantidae, Anisopterid and Zygopterid dragonflies, Pentatomidae, Lygaeidae, Coreidae, Reduviidae, Miridae, Cercopidae, Delphacidae, Cixiidae, Derbidae, Cassididae, Chrysomelidae, Hispidae, Elateridae, Cicindelidae, Ichneumonidae, Braconidae, Chalcididae, Tenthredinidae, Psammocharidae, Crabronidae, Sphegidae, Bembecidae, ants, bees, butterflies, Micropezidae, Tachinidae, and Syrphidae. Among the dominant grass, on the bank itself, was occasional *Paspalum conjugatum*.

In Trinidad, in addition to roadsides and stream margins where these pass through forest, the "traces" through cocoa fields, often covered with a sward of *Paspalum conjugatum*, are much frequented by *T. pubescens*. It is, however, significant that, in response to factors not yet investigated, and in accordance with the habit of Homoptera to restrict themselves rather to plant-associations than to plant-species, this froghopper does not always appear wherever its preferred host-plants are growing luxuriantly. One of these factors, in which apparently its requirements are higher than those of its favourite

host, *Paspalum conjugatum*, and higher also than those of the sugar-cane froghopper, *T. saccharina*, is moisture. Comparative data are recorded in the section on *T. saccharina* below.

Tomaspis incompleta, Walk. In the neighbourhood of Pará and on the Ford estate on the Rio Tapajoz this species occurred in artificial clearings, more especially roadsides, in mixed rain-forest of terra firme. In many respects its ecological requirements seemed to coincide with those of *T. pubescens*. Another point of similarity lies in the great viscidity of the nymphal "spittle". *Paspalum conjugatum* and that essentially roadside grass, *P. plicatulum*, were the preferred hosts. On the Tapajoz I found it only on the former grass, whereas at Pará the latter was perhaps preferred. Growing among these grasses at the most favourable Pará localities, an abundance of *Xyris* sp. and the sedge *Dichromena ciliata* indicated relatively moist conditions.

Tomaspis saccharina, Dist. Apart from cane-fields, the Trinidad cane froghopper occurs plentifully throughout the island, in forest clearings and roadsides wherever these traverse woods, the favourite wild host-plant being probably *Paspalum conjugatum*. It has not yet been found under strictly virgin conditions but a close approximation occurred along the 13-mile oil pipe-line from Guayaguayare to Moruga. This line traverses virgin rain-forest along a cleared track about 10 feet wide, effected largely by clearing the undergrowth, leaving the tall tree canopy practically unbroken. As a result of this general maintenance of shade, grass (*Paspalum conjugatum*), had come in only in isolated patches, where a larger tree had been felled, and the shade was interrupted. The country consists of low clayey ridges interspersed with wide silty or sandy valley plains, the former largely clothed in mixed forest and the latter in high mora (*Mora excelsa*). In a traverse made in October, 1930, not long after the track was made, I swept every patch of grass for froghoppers and found both *Tomaspis saccharina* and *T. pubescens* present, and occasionally plentiful, with an interestingly strong tendency for *pubescens* to be more abundant, or even alone, in the mora plains, and *saccharina* on the mixed forest ridges, though the host-plant was the same *P. conjugatum*.

T. saccharina was found in an artificial clearing at the summit of Mount Tucuche (3072 feet). It is often abundant on cacao estates, not only on the *Paspalum conjugatum* which frequently clothes traces, but also on the coarse weed-grass, *Setaria sulcata* (gamalote).

Tomaspis bodkini, Williams, is superficially very similar to *T. saccharina*. It is locally frequent in the Orinoco Delta in Indian provision-fields on the lateritic or sandy knolls, more especially the latter, as described in the account of *T. pubescens*, which is frequently associated with it. *Paspalum conjugatum* is the preferred host-plant, but it is found also on *Syntherisma digitata*. On the former host it was collected in the Pakaraima Mountains, in montane mixed rain-forest up to an elevation of about 2,400 feet.

Tomaspis propinqua, Walk. has not yet been found in an unaltered plant-association, but judging from its habits, affinities and host-plants it is almost certainly one of the forest clearing species. It was studied in the Valley of Caracas, Venezuela (about 3,000 feet), first in a dry cane-field ditch, full of *Paspalum conjugatum* and *Commelina* sp., the banks clothed with the former grass and with Guinea Grass (*Panicium maximum*), in places passing wholly into the latter. A second infestation was found on sugar-cane in a damp hollow, the froghoppers sitting conspicuous on the leaves, not hidden in the leaf-funnels like *T. saccharina*.

3. Riparian Froghoppers.

In connection (*a*) with the great annual rise and fall of the water-level (20 to 40 feet) and (*b*) with the heavy sediment load of its "yellow" water, the Lower Amazon (between Manáos and Pará) supports a tremendous extent of riparian grass communities, often covering a very wide zone between the water and the edge of the great Amazon forest. These associations, which reach their maximum development about Santarem, will be considered in greater detail in a contribution to plant ecology. For the present it must suffice to state that, in general, the greater portion of the actually floating grass-beds, forming the outermost zone, consists of *Paspalum repens*, mixed, as one approaches the bank, with the taller and stouter, often cane-like *Echinochloa polystachya* which frequently forms a high, pure wall on the bank itself. Behind the *Echinochloa*, and inundated only for a short period at high water, is an often much wider zone of the robust grass known as mory (*Paspalum fasciculatum*). While all three zones are inhabited by various species of cane-borers (*Diatraea*), often in great numbers, it is the third or mory zone which has been most extensively colonised by froghoppers of the genus *Tomaspis*, again frequently in tremendous infestations. These froghoppers I propose to call riparian species, since this seems to be their primitive habitat, a habitat highly specialised in many respects, and in others intermediate between forest and savannah. We have already seen that forest clearing species like *T. pubescens* may, on narrow forest creeks, become riparian species; but conditions in these Amazon grass-beds are more specialised, and obviously unsuitable for ground-dwelling species. Consequently we find the riparian Amazon forms belong to the top-dwelling species of *Tomaspis*.

Tomaspis morialis, C. and M. This is undoubtedly the most abundant of the riparian froghoppers, often present in veritable clouds, the individual mory stems showing 100 per cent.

infestation. Mass infestations were studied at many localities between Santarem and Manáos, and some old spittles on mory about 50 miles up the Rio Branco were probably of this species. On two occasions, in two stations, adults were found hidden in sugar-cane funnels. Adults also occurred infrequently on *Echinochloa polystachya*. It is a most active species in this stage.

Tomaspis tristis, Fabr., to which *T. guppyi*, Urich, of Trinidad is closely allied, shows a much wider distribution. It was found in small numbers, never a large infestation, with the preceding species on mory (*Paspalum fasciculatum*) on the Lower Amazon, once or twice under conditions that showed it had bred on this host-plant. Adults occurred in sugar-cane funnels in the Furo do Ramos. It was studied as a cane-pest in Suriname, by Williams (1917). In the heavy mixed rain-forest at the foot of the Kanuku Mountains of British Guiana it was very abundant associated with *T. pubescens* on the grass, *Hymenachne auriculata*, forming riparian beds along a forest creek (the Napi), and higher up the banks, on the naturally cleared (torrent-swept) flood-plain it occurred in a numerous pure culture on tall stands of *Tripsacum dactyloides*. On the wide leaf blades of the latter it was producing a brown discoloration closely similar to froghopper "blight" on sugar-cane in Trinidad, caused by *T. saccharina*. Another sucking insect, a delicate white Derbid, also plentiful on the *Tripsacum*, may have been associated in this injury.

Tomaspis mura C. and M. This stout but obscure form, which proved to be a new species, was found in the present investigation, on canarana (*Echinochloa polystachya*) and sugar-cane at the western end of the Furo do Ramos, Lower Amazon. The cane, nearly every plant of which was infested, was growing in a clearing made on the border between the canarana (*Echinochloa*) and the mory (*Paspalum fasciculatum*) zones. Whether it is primitively an inhabitant of the canarana zone I do not know, as we found no nymphs in a long search; but it is evidently a riparian form. One adult was taken on adjacent mory; but this is probably not a regular host-plant. Another specimen was seen further west, in the Paraná da Eva, in a cane funnel in the mory zone.

4. Savannah Froghoppers.

When one considers the dry conditions which the various stages (chiefly eggs) of the sugar-cane froghopper (*T. saccharina*) are forced to support in the cane-fields of Trinidad during the dry season, it becomes evident that a parasite of a savannah froghopper would have greater chance of success against our pest than one attacking froghoppers of a continuously moist rain-forest habitat. Consequently special search was made for a savannah- (or natural grassland-) dwelling froghopper. This search, if we except a stray adult *saccharina* caught on a tiny upland savannah of the Northern Range, was always unsuccessful in Trinidad. The first true savannah froghopper to be found was a large pale brown form on the island of Marajó at the mouth of the Amazon. It proved to be *Tomaspis terrea*.

Tomaspis terrea, Germ. The savannahs or *Campos* of Marajó are divided by elevation into *baixos* and *altos* (low and high), the former covered with several feet of water in the wet season. They are characterised by very different vegetation, the dominant grass on the lower savannahs being *Panicum laxum*, and on the higher, *Trachypogon plumosus*. Other grasses of the lower campos include *Sacciolepis myuros*, *Paspalum densum* and *P. pleostachyum*, with many sedges (*Cyperus articulatus*, *Eleocharis geniculata*, and *E. mutata*) and *Thalia geniculata* in the wetter parts, a few plants of *Ipomoea crassicaulis*, and occasional isolated small trees such as *Byrsonima crassifolia*. The higher campos bear scattered trees of *Curatella americana*. Both types of campos may, however, be clear of bushes and trees for miles, or even to the horizon, or, on the other hand, diversified with bush islands containing numerous palms, especially *Astrocaryum jauari*, an *Acrocomia* and a *Desmoncus*. These bush islands are usually fringed by *Paspalum virgatum*, here taking the place of *P. anceps* of the Rupununi-Rio Branco savannahs.

Nearer the sea the lower campos are covered very largely with *Sporobolus virginicus*, with patches of *Paspalum pleostachyum* on slightly higher ground.

Tomaspis terrea occurred in some abundance low down inside the clumps of the fine-leaved tall razor-grass (*Paspalum pleostachyum*) of the lower campos. It was common also on the less abundant razor-grass (*P. densum*) near the same station.

Tomaspis picklesi, C. and M. The second savannah froghopper was discovered by my assistant, Mr. D. Vesey-Fitzgerald, on the somewhat higher and much smaller campos of Santarem, Lower Amazon. These Santarem savannah are mostly of a closed type, with frequent small trees, and numerous scattered clumps of diverse bushes—*Anacardium occidentale*, *Curatella americana*, *Byrsonima* spp., *Plumeria*, *Davila radula*. There are, however, occasional large open spaces covered with low grasses and Eriocaulaceae, especially, among the former, *Paspalum carinatum*, with clumps or even extensive stands of *Trachypogon plumosus* and, in the shade of the low trees, a stout, pale green sedge. Termite mounds up to four feet high are widely scattered. The soil is a loose sand or a thin layer of this overlying hard compact silt. *Tomaspis picklesi* was attached chiefly to the small grass, *Paspalum carinatum*. It was the subject of intensive ecological study by Mr. and Mrs. Pickles.

Tomaspis rhynchosporae, C. and M. This tiny species, the smallest known *Tomaspis*, was discovered at the base of Mount Roraima, in open savannah, first at about 4,000 feet. Here a small stream led a band of swamp across the drier general *Trachypogon-Byrsonima* savannah. Between the

swampy strip and the latter was a zone marked by abundance of a tall wiry *Andropogon*, growing among a small, fine-leaved Paspalum (*P. hyalinum*). The little froghopper was entirely confined, both as nymphs and as adults, to this *Andropogon* zone, though its only host plant was the sedge, *Rhynchospora barbata*, which itself extended abundantly into the *Trachypogon* zone. This would appear to be another instance of a Homopterous insect attached less to a botanical species than to a definite plant-association, determined in this case apparently by position on the moisture gradient from stream-bed to dry savannah. *Tomaspis rhynchosporae* was later found in a similar habitat on Mount Roraima at an elevation of about 6,300 feet, and also widespread but scarce, on the Rupununi savannahs of British Guiana. Mr. Pickles and I later found it on a small edaphic savannah near Pará, always in association with *Rhynchospora barbata* or closely allied species.

Tomaspis flavilatera, Urich, was first recorded as a sugar-cane pest in the coastlands of British Guiana. In May, 1929, I had an opportunity to examine a heavy but very localised infestation at Plantation Ogle. Most of the nymphs and adults were not on the canes, but on Bermuda (Bahama) grass (*Cynodon dactylon*) at the margins. I could obtain no clue as to the primitive status or original host-plant of the insect, and it was not until Mr. Vesey-Fitzgerald discovered an infestation on Mount Roraima, at about 6,300 feet, that my suspicion that it was a savannah froghopper was confirmed. Here it was in association with *Tomaspis rhynchosporae* and the host-plant seemed to be the same sedge (*Rhynchospora barbata*) growing in savannah among *Paspalum contractum*, *Trachypogon plumosus*, the tall sedge, *Lagenocarpus* sp. and the curious Bromeliad, *Brocchinia cordylinoides*. *T. flavilatera* was, however, concentrated in a zone where all these plants were growing under slightly drier conditions than those favoured by *T. rhynchosporae*, so that, though occurring within a few yards of each other, their respective ranges did not, according to my observations, overlap.

5. Actual and Potential Sugar-cane Pests.

Mr. H. E. Box has put forward the view that all species of moth-borers of the genus *Diatraea* should be considered and studied as potential pests of sugar-cane. The history of successive inroads on this crop by indigenous neotropical insects since its introduction from the East, and the extraordinarily wide range of conditions under which it will flourish, go far to justify this view and to support also its application to the froghoppers of the genus *Tomaspis*.

At present, within the area under discussion, the only serious sugar-cane pest-froghopper is *Tomaspis saccharina*, which occurs in Trinidad, Grenada and (rarely) in St. Vincent. The next most damaging, but never more than localised and sporadic is *T. flavilatera* in British Guiana. *T. tristis* is recorded as an occasional pest of sugar-cane in the Dutch Guiana coastlands, and was seen attacking this plant on the Lower Amazon, where also *T. morialis* and more frequently, *T. mura*, also attack cane when it is planted in the riparian zones which form their normal habitat. Finally *T. propinqua* is a sugar-cane species in the Valley of Caracas, but has never been recorded as a serious pest.

6. Summary.

1. Fifteen species of the genus *Tomaspis*, related to the sugar-cane froghopper (*T. saccharina*) have been studied ecologically during the search for parasites in Trinidad and from Venezuela to the Amazon.

2. Ecologically they may be divided into forest forms (8 species), savannah forms (4 species), and intermediate between these, the riparian forms (3 species).

3. The forest species include those confined to virgin rain-forest (2 spp.), those affecting second-growth (1 sp.) and those feeding on the low grasses which invade natural or artificial clearings (5 spp.)

4. The savannah forms are considered worthy of a special study since a parasite attacking them would have more chance than a rain-forest insect, to adapt itself to dry cane-field conditions.

5. Of the 15 forms studied, six frequently or occasionally attack sugar-cane, especially when it is planted in the same stations as the plant-associations to which they are primitively attached.

6. Only one species, *T. saccharina*, is relatively thoroughly and continuously adapted to cane-field conditions, but all should be considered potential pests.

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CONTROL OF GRAPEFRUIT DISEASES BY CULTURAL METHODS IN TRINIDAD.

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Introduction.

In compiling this article the writers assume that it is now generally accepted in this colony that the establishment of a commercial plantation of any variety of citrus by means of seedlings is definitely out of date, and that the only really reliable *modus operandi* is by budding the desired scion on to sour-orange stock. There is still some difference of opinion in regard to the relative merits of sour-orange and rough-lemon as stocks. It is often stated that the latter is preferable on light land and the writers have seen young grapefruit plantations where the growth on rough-lemon was consistently better than those budded on sour-orange. On the other hand, there are experienced planters who state that this early advantage is lost in later years and that sour-orange gives better results where continued cropping is the aim. There is much investigational work to be done on citrus stocks in general in the British West Indies and elsewhere and, until such time as this work yields results, the writers feel that grapefruit planters would be well advised to use only sour-orange stocks whether their land be sand or silt. Sour-orange has given consistently good results on varying types of soil whereas there is some doubt as to the length of service given by rough-lemon. It is possible that a species of wild grapefruit or other citrus variety may prove better than either of these two stocks but until sufficient evidence is forthcoming, sour-orange should be the standard stock in Trinidad.

The general opinion tends to favour light rather than heavy land for grapefruit and, as so often happens, the tendency is to plant on too light land. Such lands may prove uneconomic in the future when production becomes increased sufficiently to reflect a drop in prices and owing to the increased amount of artificial fertilisers they will require concomitant with rapid leaching. Heavy lands in general have been objected to on account of the increased incidence of Gummosis and other maladies. If the recommendations given below are followed these objections will largely be eliminated.

Damping-Off.

"Damping-off" is a descriptive term applied to the effects of several soil-inhabiting fungous parasites which attack young citrus and other seedlings at ground level and, in the majority of cases, cause death. Several of the organisms associated with "damping-off" of citrus seedlings in other parts of the world may be present and active in the same capacity in the British West Indies but in the few cases where cultural work has been carried out the fungus isolated has belonged to the genus *Phytophthora*. The specific identification of the parasite as *Phytophthora parasitica*, Dastur has been made in one case in Trinidad by one of us (Baker), but other organisms may sometimes be responsible. This, however, is only of technical interest since the conditions conducive to "damping-off", the effect on the seedlings, and the means of control are identical. The "damping-off" fungi produce water-soaked lesions on the stems near ground level which rapidly extend completely to girdle the seedling. At a later stage the diseased tissue may or may not turn brown and shrink, but in any case the majority of the youngest seedlings bend over at the point of attack near ground level, wither and die. Older seedlings which have developed more woody tissue may be killed without bending over.

The disease breaks out in small patches at first but these rapidly increase in size if favourable conditions remain unchanged, thereby accounting for the loss of most of the seedlings in the box or seedbed. The losses caused by "damping-off" organisms can be effectively controlled, but consideration of the necessary measures is deferred to the general section on disease control for simplicity of reading and reference.

Scab Disease (Sporotrichum citri, Butler).

Scab disease occurs in many different countries on several varieties of citrus. It attacks fruit, twigs, and leaves. The present account, however, deals only with the disease as it affects sour-orange seedlings which are being grown as stocks for grapefruit or other citrus varieties.

There are districts in which sour-orange seedlings can be grown comparatively free of the disease whereas in others the seedlings are regularly very badly attacked.

The disease appears on the seedlings while they are still young. The attacked leaves are characterised by irregularly shaped scabby or wart-like projections. Infection takes place on both sides of the leaves but is more usual on the under surfaces. The stem is also affected. The warts or scabs are light brown in colour and the corresponding tissues on the other side of the leaf frequently become depressed or develop similar wart-like projections. The warts vary in size ranging from 1 to 5 mms. in diameter. They may be single or in groups and frequently coalesce to cover large areas of the leaves. When young unfolding leaves are attacked they invariably become distorted or wrinkled, and the diseased tissue is often torn owing to the pull exerted by the expanding healthy tissue in growth. In severe cases the growth of the young seedling is arrested and the growing point frequently

killed. This check results in a stimulation into growth of the buds in the axils of the lower leaves so that a seedling six inches high may have as many as six branches. It becomes necessary, therefore, to remove five of these branches in due course leaving the strongest and best placed one to continue growth. This cycle may be repeated several times so that it may take more than two years before the stock grows to a height suitable for budding. In the meantime the stem is crooked in shape and the tissues are hard with the result that they cannot possibly be considered as first class nursery stock after budding.

Not infrequently, badly scabbed sour-orange plants become susceptible to a heavy infestation by scale insects and the combined effects result in the death of the plants.

The incidence of the disease in Trinidad depends on weather conditions. A seedling which has been badly affected in the rainy season produces perfectly clean growth when the rains cease. In some countries temperature is a factor of importance but not in this colony because the fungus can grow throughout the existing ranges.

Gummosis.

Gummosis is the most serious disease of 'Marsh' and other varieties of grapefruit in Trinidad, and during the past few years it has caused considerable losses of trees four or more years old. Younger trees are seldom attacked. The organisms causing the disease are *Phytophthora parasitica*, Dastur and a strain of *Phytophthora palmivora*, Butler differing from the common West Indian 'cacao' strain of the species in that it will not attack cacao pods. *Phytophthora citrophthora*, (Sm. and Sm.) Leon. has not been found in Trinidad.

Phytophthora parasitica and *Phytophthora palmivora* are closely allied species and can only be distinguished by careful study in the laboratory. In the field their symptoms are identical, and control methods suitable for the one are applicable to the other.

The detection of the disease in the field is not always a simple matter. Drops of gum exuding from the bark of a tree are a good indication of the presence of the disease; but it must be remembered that the formation of gum is a normal response of the tree to wounding and will flow from cuts and from wounds made by insects. Conversely cases of the disease have been observed in which either no gum has exuded or only a few drops were formed at a late stage. The flow of gum from a wound depends on the season and on physiological factors which have not yet been investigated. In order to diagnose the disease correctly in the field it is necessary to examine the trunk of the tree carefully for dead bark, and to observe the dark brown stain which is left on the wood after this dead bark has been removed.

It is well-known that sour-orange is normally highly resistant to gummosis and that 'Marsh' grapefruit is highly susceptible. It is on the susceptible grapefruit scion just above the bud union that the attack most frequently originates. Attacks of gummosis on the sour-orange stock are exceedingly rare even under environmental conditions quite unsuited to grapefruit culture. The majority of the older trees were budded too low (*i.e.*, four to six inches above ground level), were allowed to branch too low, and were planted in holes instead of on mounds. Such trees have suffered severely from gummosis and many of them have died. Careful attention to inarching, drainage, pruning, cutlassing and round-weeding may prolong the lives of these trees for a few years while a replacement programme is being carried out, but they can never be wholly satisfactory.

Root-Rot.

Recently it has become evident that 'Marsh' grapefruit trees worked on sour-orange stock in Trinidad often suffer from root trouble. Instances of trees unaffected by gummosis showing symptoms of wilting followed by death have been frequently met with during the past year. The symptoms are as follows:—The foliage of a tree, which a short time previously appeared normal, quite suddenly turns bright yellow and the leaves begin to fall. Simultaneously a heavy crop of small fruit, usually borne in large bunches is set. Examination of the root system will generally show that at least half the roots are dead. The distal ends of the roots appear to have died first in the majority of cases examined. Subsequently they have slowly died back as far as the collar of the tree. As soon as the collar was ringed, or all the main roots killed, the tree died. The bark of such roots is water-soaked, soft and spongy, and at first of a dirty yellowish-brown colour, but turning black later. The wood is similarly discoloured. This black discolouration is generally caused by a profuse growth of the semi-saprophytic fungus *Botryodiplodia theobromae*. Isolations from recently infected tissues yielded cultures of *Fusarium lateritium*, var. *fructigenum*, *F. sambucinum*, *F. semitectum*, *Phomopsis* sp., and other obviously saprophytic organisms. No primary parasite has so far been discovered.

In cases of Root-Rot death of the tree follows much more rapidly than with Gummosis and moreover the fruit is more seriously affected. Fruit from trees with Gummosis disease, unless they are obviously dying, appear to be quite normal*, while fruit from trees with root disease are useless. The skin of such fruit is generally thick, the pulp coarse and lacking in juice, and they possess an objectionable 'quinine' flavour. Fruit of this type should on no account be exported, or used in the preparation of grapefruit juice or canned grapefruit.

* This matter is under investigation at the College Low Temperature Station.

Further investigation has shown that most of the affected trees were growing in situations subject to water-logging; being either on heavy undrained land, or in areas subject to high rainfall. In some cases also, careless round-weeding had produced a saucer-shaped hollow around the tree, which filled with water during heavy rain and increased the trouble.

Root-Rots of citrus trees caused by excess water have been noted in other countries (1), and there can be little doubt that this is the explanation of the trouble in the present instance. Most of these cases of Root-Rot occurred during the very long and severe dry season of 1934. The previous wet season had also been abnormally long and severe, and many grapefruit fields had been water-logged for prolonged periods. Many of the roots were probably killed at this time, and the trees were left with an inadequate root system to face the severe 1934 dry season and therefore died.

Threadblight. (Corticium Stevensii and Marasmius sp.)

Both the Corticium and the Marasmioid forms have been found on grapefruit in Trinidad, but never to any serious extent, and only in the wetter areas of the island. In a previous paper (3) the writers were able to identify the Corticium threadblight as *Corticium Stevensii*, Burt. but since no fructifications of the Marasmioid form have so far been found, specific identification has not been possible. It is, however, very similar both in morphological and cultural characters to a Marasmioid threadblight of *Coffea arabica* and *Coffea robusta* which is occasionally seen in Trinidad. Seriously affected branches should be cut out and destroyed; but since threadblights are definitely correlated with wet conditions, it is a better policy to control the disease by improving conditions under which the trees are growing.

Septobasidium sp. (S. pseudopedicillatum, Burt ?)

A fungus of the genus *Septobasidium* closely resembling *S. pseudopedicillatum*, Burt, has been found on grapefruit trees in several districts (4). The definite identification of the species must remain in doubt until spore-bearing specimens of the fungus are found. Up to the present all the material examined has been sterile. Fawcett and Lee (2) state that on citrus the fungus is entirely superficial and does not appear to penetrate the bark, but only harms the tree indirectly. The writers agree with Fawcett and Lee that *Septobasidium* sp. is not a serious disease, since it does not usually cause sufficient damage even to justify pruning out affected branches. Under very wet conditions, however, the fungus can grow luxuriantly on the trunk, main limbs, twigs and leaves of grapefruit trees, and subsequent defoliation and death of branches less than one inch in diameter is by no means infrequent.

Pink Disease. (Corticium salmonicolor, Berk. and Broome.)

This disease is of rare occurrence and its presence is correlated with periods of heavy rainfall. It can easily be recognised by the light pink film of mycelium and spores which it forms on the outside of the bark. The mycelium is superficial at first but later penetrates the bark. Pink disease can cause considerable damage to grapefruit trees, since affected branches become defoliated and finally killed. Diseased branches should be cut out.

General Consideration.

The object of this paper is to inform planters how to establish a plantation of 'Marsh' grapefruit in the best manner to avoid disease and, apart from manurial treatments which must vary with different soils, the age of the trees, and the rainfall, to maintain cropping capacity over a long period of years. The writers consider that to attempt to establish large areas of grapefruit by rushing through hundreds of thousands of poorly grown nursery plants on the plea that they cost little is an unsound policy. Moreover, they are aware that some of their recommendations will be considered at the present time to be too refined and to aim at a standard possible of attainment only in temperate regions. It is to be pointed out, however, that there are already planters in Trinidad who regularly produce first class nursery stock on their own estates, and that these need but slightly modify their methods to follow the recommendations made herein.

SEEDS.

Recommendations are sometimes made to select seed for size and shape from healthy fruits from good bearing sour-orange trees, and that in practice 40 to 60 per cent. of the seeds have to be discarded because they are thin and poor in size. The present writers consider that such a rigid selection is unnecessary. The important points in seed selection are: (*a*) to choose seed only from fully ripe fruit, (*b*) to float off in water and discard the flat, light and undeveloped seed, (*c*) to sow the seed while still fresh before they dry out. This will ensure an even stand of seedlings with few or no bench roots. Seedlings raised from dry and hard seed give rise to plants a large percentage of which develop bench or twisted root systems.

SEEDLINGS.

The time of sowing the seed depends to a large extent on weather conditions which define the date of ripening of sour-orange fruit. In the main, however, the best time to sow is in the month of February. Where large numbers of seedlings are required the usual method is to plant out in raised beds which are about four feet wide. This method, however, has several disadvantages. Firstly, the soil may at this time of the year be excessively dry and the percentage germination reduced accordingly. This factor may be overcome by watering or by means of irrigation.

Either method is apt to result in an attack by "damping-off" fungi. Secondly, watering with a watering can or hose causes a packing of the soil with its concomitant bench-rooting of the seedlings, and in any case a shallow root system. Thirdly, watering and subsequent rain causes the splashing of soil on to the tender tissues of the stem and leaves which may result in the death of the seedlings. The best method of raising seedlings is that which is being practiced so successfully by Mr. W. S. E. Barnardo in Trinidad. Finely chopped coconut fibre which has been thoroughly dried in the sun is soaked for a few minutes in a wooden or enamel vessel containing Cheshunt mixture*. The soaked fibre is then placed in wooden boxes or open framework which are about 9 to 12 inches deep and are otherwise of a convenient size. The seed is then sown evenly and not too thickly just below the surface of the fibre. Subsequent waterings with Cheshunt mixture are given every three to five days as required.

Cheshunt mixture is easy to prepare, costs little, has definite manurial value, and effectively prevents "damping-off". It has also been recommended to water soil with Cheshunt mixture when "damping-off" disease appears. In the writers' experience this compound is ineffective once "damping-off" has appeared in the bed.

In order to prevent the development of scab-disease, the boxes, after sowing, should be placed in a position where direct sunlight does not strike them at any time during growth. On the other hand the stronger and more evenly distributed the reflected light the better. Moreover, the shade-producing structure should be waterproof so that no rain falls on the seedlings. If the boxes are placed under the eave of an estate building care should be taken to turn them at intervals, otherwise the stems of the seedlings will bend over towards the side on which the light is strongest. A good method is to erect a cheap structure with Timite palm (*Manicaria saccifera*) leaves or corrugated iron on bamboo supports. The height of the structure should be about 4 feet 6 inches above ground level to allow of good lighting commensurate with economy of material.

The seedlings should be transplanted into the seed beds at the beginning of the rainy season in June, and if sown in February they will be about a foot high. Seedlings raised in finely chopped coconut fibre in the manner described develop excellent taproots and, moreover, the seedlings can readily be removed from this medium with the minimum of damage to the delicate rootlets. Only seedlings with well-developed and straight taproots and shoots should be planted. All other should be discarded and since this is an important point about four times as many seed should be planted as budded plants required.

* *Preparation.*—Thoroughly powder 2 ozs. of Copper Sulphate and 11 ozs. of Ammonium Carbonate then mix and store in sealed glass vessels for 24 hours. Take 1 oz. of the mixture and dissolve in 2 gallons of water. Cost 48 cents per 100 gallons.

Preparation of Nursery Beds.

The site for the nursery bed should be on the best soil on the estate and where frequent inspection is possible. Soil in good tilth is comparatively rare in Trinidad and unless rich and free draining soil is available special preparation by liming, manuring heavily with pen manure, and cultivating to a depth of 18 inches is necessary. Drains should be dug at intervals of about 12 feet in order to supplement the effect of the lime, pen manure and deep cultivation in the production of a deep root system which is essential in a citrus nursery. The nursery beds should be covered with artificial shade effected by coconut leaves on bamboo and wire supports. Coconut leaves allow rain to penetrate on to the beds, are cheap, and last for as long as they are required.

Excellent stocks can be raised free of scab disease under the shade of cacao and this method is cheaper than constructing artificial shade. There are, however, one or two points which are worthy of consideration when growing citrus nursery stock in the shade of living plants. The method followed by those who establish small nurseries under cacao is to plant out the sour-orange seedlings between the existing trees. The mulch of cacao leaves effectively protects the plants from drip effect, and the seedlings produce straight stems free of scab. There are times, however, when rain falls soon after budding—and this is followed by failure of the buds or withering of the delicate young scion shoots. A better method—indeed the best and cheapest way where cacao is available—is to cut out the cacao trees in one bed, and to supply with good quality cacao seedlings from high yielding parents and at the same time grow in the clearing sour-orange seedlings. There is no cacao estate in Trinidad which would not be the better for such a system of replanting with selected varieties of cacao (6). When the young stocks have been worked with grapefruit the cacao trees on the bordering two beds should be pruned to allow in light and air, so that the young grapefruit trees will produce sturdy shoots. In the following year, the nursery could be established on another bed, but not the adjoining one, otherwise the shade will be reduced beyond the critical point at which scab disease develops. This method has the advantage over the old method, because the scion growth after pruning the cacao in the beds adjoining the nursery will be stronger and better shaped owing to the increased admission of light. Moreover, it avoids the difficulty and damage to the root systems of both the cacao and young citrus trees which results when the latter are lifted. The same objection applies to such shade plants as papaw, and, moreover, the shade of the latter, particularly that of the male trees, is too light except when they are planted too close for practicable double cropping.

CONTROL OF GRAPEFRUIT DISEASES BY CULTURAL METHODS IN TRINIDAD.

FIG. 1. *Septobasidium sp. on branch and leaves of Grapefruit.*

FIG. 2.—*Gummosis caused by Phytophthora parasitica at the bud union of a 'Marsh' grapefruit tree on sour-orange stock.*

[illegible]

[illegible] *higher up a 'Marsh' grape-fruit tree. Diseased bark excised to show the dark brown stain on wood.*

FIG. 5.—*Young sour-orange* [illegible] *Left 'bench-rooted' seedlings*

FIG. 6.—Left, *healthy one year old sour-orange stock grown under shade. Note spot on stem at 24 inches above ground level which is the optimum height for budding.* Centre, *healthy sour-orange stock about one year old grown in the open under favourable conditions. Note spot at height of 18 inches above ground level which is the maximum possible height for budding on this stock.* Right, *sour-orange seedling eighteen months old grown in the open under unfavourable conditions. This is quite*

FIG. 7.—*Sour-orange seedlings 18 months old, grown in the open under unfavourable conditions. Scab disease has necessitated trimming of the stocks on the left and centre to avoid the result in the seedling on the right. All three are also affected by 'ben h roots' and are therefore, undesirable nursery material.*

Transplanting of the sour-orange seedlings should be done with care so as to avoid damage to the root system, and for this work the task system of paying labour should be avoided. At least twice as many seedlings should be planted as budded plants required to allow for selection of the best plants for budding. The interval of planting should be two feet six inches between rows on the diagonal system or three feet if planted on the square. The distance of planting at present is 18 inches which is satisfactory for trees planted out when 17 months old from sowing time. The writers, however, advocate keeping the plants for an extra twelve months in the nursery, for reasons which are discussed later.

After planting out in the nursery the beds should be heavily mulched with vegetable material. This is important because it protects the stems of the seedlings from becoming covered with mud splashed on to them by the heavy rain drops from the shading coconut leaves.

Artificial shading of nursery beds costs money but this is off-set by the following facts:—(i) only one or, at most, two weedings will be required in the first year, (ii) little or no trimming of the plants will be required, (iii) the strong-growing straight-stemmed plants will be infinitely better material to serve as stocks, and, (iv) a year will be saved in the time between sowing and the production of a stock workable at the required height.

As the dry season approaches, the shade should be gradually thinned and later removed altogether so as to harden off the wood. There will be no danger of scab disease in the dry weather.

Budding may be done from any time after Christmas up to March, but with stocks grown under shade, time should be given to harden off the wood.

In order to avoid Gummosis in after years, budding should not be done below a height of 18 inches from ground level, and is unnecessary and inadvisable above two feet. The following table taken from a previous publication (7) shows the reason for advocating 18 inches as the minimum height for working grapefruit trees on sour-orange.

Two feet is given as a maximum height in order that strong scion growth may be produced which can be made to branch at four feet from the ground. Trees branching at a height lower than four feet bear fruit which weigh down the branches thus effectively shading the crown of the tree from the sun. This is conducive to gummosis, exaggerates the evil effects of wet land in the rainy season (Root-Rot), and, moreover, has a profound influence on the amount and quality of the fruit particularly when the trees are young. As a general rule young trees produce thick-skinned fruit but as they grow older the skin becomes thinner and the quality is improved. If sunshine and air are admitted to the crowns of young trees the soil will dry out more in the dry season, the crop of fruit will be heavier and *ipso facto* of better quality. This will be further discussed later. It is not proposed to go fully into the technique of budding and staking grapefruit which has been adequately dealt with in other publications (5 and 8) but there are two points which are of some practical importance and which may be mentioned. The practice of greenstick-breaking the scion about six inches above the bud is said to protect the bud from the direct rays of the sun during dry weather. The writers suggest that this waving spiny flag of growth is ineffective in protecting the bud from the sun and the spines are prone to tear healthy leaves. It is better to cut the stock clean off six inches above the point at which the bud is inserted and to insert the bud on the more shaded side of the stem. When the time comes to remove the projecting stock above the scion it is important to do so by means of a long slanting cut in preference to a cut more or less at right angles to the line of growth. The oblique cut induces growth more in line with the stock whereas following a square cut the tendency is for the scion to grow out at an angle. This is an important point in nursery work as well as when cutting more mature trees. Nichols (5) states that "to obtain a well-shaped citrus plant a minimum of three, and a maximum of seven, lateral branches should be produced radially between 28 and 35 inches from the ground. The

TABLE I.—Gummosis of 'Marsh' Grapefruit.

Field.	Age of tree (years.)	Number of trees examined.	Mean height of bud union (inches).	Mean height of first fork (inches).	Percentage with gummosis on grapefruit scion.		Percentage with gummosis on sour-orange stock.	
					Total.	Serious.	Total.	Serious.
A	5-6	125	4.17	16.0	63.0	40.0	17.0	**2.0**
B	7	98	4.44	10.6	78.0	49.0	18.0	**2.0**
C	6	100	4.56	18.6	52.0	35.0	15.0	**0.0**
D	5	135	5.13	18.2	36.0	20.0	8.0	**1.0**
E	8-12	632	5.20	17.8	28.5	13.0	14.0	**0.2**
F	8	155	5.98	14.5	59.0	27.0	13.0	**0.0**
G	8-10	50	**6.96**	22.5	**4.0**	**4.0**	**0.0**	**0.0**
H	5	100	**8.30**	23.8	**2.0**	**0.0**	**0.0**	**0.0**
I	5	150	**11.80**	29.4	**2.0**	**0.0**	**0.7**	**0.0**

lateral branches should be spaced as widely as possible, or otherwise excessive strain localised in a small area is likely to lead to branch fracture and subsequent malformation of the tree". The present writers consider that the lowest branch should come off at a height of four feet above ground level, that no more than four branches should be allowed to grow and that the relative position and height of these should be accomplished by cutting back the leading shoot at a height of about four feet six inches and *removing with the thumb nail or budding knife those buds which are not required to grow out to form branches.* All branches that develop below four feet from the ground should be cut out. When the side branches have grown to a length of 18 inches they should then be cut back to a length of one foot and two buds, or three at most, be allowed to grow until about a week before the time of transplanting when they should be cut back to a length of about nine inches to a foot depending on the strength of their growth. Until the plants are ready to leave the nursery it is advisable to remove all subsidiary branches in order to produce a strong well-balanced scaffolding of main branches.

In order to grow the young trees to the stage above-described it will be necessary to keep them in the nursery an additional 12 months. This is recommended on the grounds that it is easier and cheaper to attend to the trees during this critical period on the small area covered by the nursery than on the larger acreage covered by the trees after they have been planted out. Transplanting induces subsequent jorquetting which is not desirable, particularly when the trees are young. As a general rule trees of this size should be transplanted without a ball of earth (*pelan*), preference being given to the bare-root system. Judging between the bare root and pelan systems of planting even one-year old trees depends largely on the weather conditions prevailing at the time of transplanting and, as with all other operations, on the quality and amount of supervision given.

The young trees should be planted on mounds which need not be more than 18 inches high at the centre and five feet wide so that the slope is gradual. The tendency at present is to make the mounds too high and too narrow. Moreover, the soil should be thoroughly cultivated to a depth of nine inches below the mound. This allows for the even and uncramped distribution of the trimmed tap-root and lateral branches of the root system. It is most important that the young trees should be planted firmly in the soil.

Drainage.

In land cleared of forest it would perhaps be difficult and expensive to dig a drainage system before planting out the trees, but the writers would stress the advisability of establishing a drainage system before planting whenever possible. In Trinidad prolonged postponement of draining has caused the death of many trees from Root-Rot following periods of water-logging. In any case lack of drainage results in a shallow root system ill-adapted to withstand dry season conditions. Moreover, subsequent drainage will not lead to the production of a satisfactory tap-root. Even when drains cannot be dug prior to planting it is highly desirable that their position be decided upon, so that the trees may be planted in the best situations relative to them. Too much attention to neat alignment of trees irrespective of the topography of the land leads to ineffective drainage.

Interval of Planting.

The normal distance of planting is 30 by 30 feet on the square. This is rarely the optimum under the varying conditions of soil and rainfall in these islands. Grapefruit is generally planted on land where the owner has had no previous experience of the growth of citrus. The writers therefore recommend that the trees be planted out in rows between drains 25 to 30 feet apart, depending on soil texture, and that the interval between the trees in the rows be 18 feet. On some lands this can be taken as the permanent position of the trees, but the future policy to be adopted must be judged from the response of the trees after planting. If growth is slow, as it will be on light land in a dry area, the trees will bear fruit early, and only normal cultivation and manuring be required. If, on the other hand, they make rapid growth, alternate trees in the rows should be ringed-barked by means of thick strong fencing wire at the end of the first year after planting and about a month before grapefruit trees in general are expected to flower. After these ringed-barked trees have flowered the wire should be removed. In the following seasons, fruit from the ringed-barked trees will be smaller and more regular in size, less coarse and with a thinner skin than that borne on the unringed trees. The unringed trees will grow much more rapidly than the ringed ones and will eventually become dominant. When they have grown sufficiently to cause overcrowding, the ring-barked trees, which can be looked upon as a long range catch-crop, must be felled and removed.

In all except the lightest soils, drains should be dug between each row, and the width of the beds between drains (and therefore the distance between the rows of trees) must depend to some extent on the texture of the soil. The minimum distance advised between rows (25 feet) should be used on heavy land, and the maximum (30 feet) on good loams, as in general the trees will make less growth on the heavier soils. When laying out the field it must be remembered that the nature of the subsoil is as important as that of the surface soil.

Maintenance.

A survey of grapefruit estates five years old or more in Trinidad indicates that an annual cleaning up of the orchard is necessary. This

should be carried out immediately after the crop is reaped and prior to the next flowering. All dead branches should be cut out, and all low-hanging branches which have been pulled down by the weight of the crop must be trimmed. At the same time the trees should be sprayed. The spray should be capable of killing scale insects, moss, and patches of fungi like *Septobasidium*, which are of constant occurrence particularly in districts with a high rainfall. Manures should generally be applied at this time, but no recommendations can be made either of the amount to be applied or the composition of the mixture, since these must depend on soil, previous cropping, rainfall and so forth. This latter problem must be settled by inspection of the individual trees at intervals throughout their life cycle.

Future Possibilities.

When the grapefruit trees already planted in Trinidad come into full bearing there will inevitably be congestion at the packing shed and possibly some difficulty in shipping arrangements to cope with a crop all of which comes into maturity more or less at the same time. It is true that the packing shed can be enlarged as the amount of fruit increases but anything which tends to spread out the period of maturity of the crop in different parts of the same estate will lead to economy in labour, reduced overhead charges in the packing shed, and better market prices.

It is too early as yet to make any recommendations as to how to bring this about, but preliminary observations and small scale experiments suggest that research work to investigate the influence of mulching versus no mulching in the dry season, light shade versus no shade, and pruning versus no pruning, might bring forth results of considerable scientific interest and practical value. The tendency towards biennial bearing which will inevitably become apparent in mature trees need not increase the difficulties.

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THE CURING OF GINGER.*

Of the two methods of curing ginger (1) sulphur curing, (2) ordinary curing, the former, which had a number of advantages over the ordinary curing, has now to be discontinued owing to the regulations introduced in most importing countries prohibiting the sale of ginger containing sulphur dioxide. An investigation was made by the Department of Agriculture, Ceylon, to discover whether equally good samples of ginger could be prepared without the use of sulphur. The most suitable variety was found to be the Cochin, which if cured in the proper way gives a plump light buff coloured product of good aroma, flavour and fracture. A period of eight to ten days of sunshine is essential for curing. If rain falls on the ginger during this period, mould and a musty flavour are developed which no amount of washing and drying will eliminate. To obtain a light coloured product curing should begin as soon as the crop is harvested. If more than is required for a day's peeling has to be harvested, the rhizomes should be placed in a well-aired room in small heaps, dry soil being spread over successive layers of ginger. As soon as harvested the ginger is first washed to remove all earth and then soaked in clean water till the following morning. Peeling is the next operation and this may be either rough peeling for the local market or clean peeling for the English market. Clean peeling is expensive and only 10-14 lb. per day can be cleaned by one peeler. As soon as peeled the rhizomes are placed in water and the gummy exudation removed by washing. Several more washings and soakings are given, as this is one of the most important operations in ginger curing. When washing is complete the ginger is spread on cement or bamboo tables to dry, rock slabs being better still. Drying takes 5 or 6 days during which time the ginger must be turned several times daily. When quite dry the ginger is washed again a process which improves the colour considerably. This washing is only used with clean peeled ginger for the foreign market. The final drying takes 3-4 days. Crude peeled ginger in India is sometimes soaked in a mixture of red earth and whitewashed and then dried. This prevents the growth of mould. (A newly devised ginger peeling knife is illustrated.)—(*Horticultural Abstracts*, Vol. IV. No. 4 p. 239, 1934.)

* Joachim, A. W. R., *Trop. Agriculturist*; 1934, LXXXIII. pp. 212-16.

AGRICULTURAL LABOUR IN TRINIDAD.—*Continued.*

BY

C. Y. SHEPHARD.

Annual and Seasonal Fluctuations in the Demand for, and Supply of Agricultural Labour.

IV.—THE SUGAR INDUSTRY.

The activities of the peasants, which vary from year to year, also vary at different periods of the year. Except where the soil is too poor, cane-farmers usually replant during the dry season to secure the advantages of a 12 months' crop, and cheap planting material provided by the immature top joints of cane cut for the factory. Cane planting is very laborious. Considerable planting takes place when price prospects appear favourable. Poor prices discourage farmers and restrict credit, so that less planting takes place. During the farmers' planting season the supply of labour is reduced by an extent which varies with the price of sugar.

The average production of cane by each cane-farmer is less than 20 tons. Their cane plots are small, scattered, and often inaccessible to cane carts until the dry season is well advanced. Since the sucrose content of the canes is normally low at the commencement of crop, and farmers' canes are purchased by weight, the estates prefer the delivery of farmers' cane to commence a week or so after the beginning of the crop season. The supply of farmers' canes usually diminishes rapidly towards the end of the crop. During the opening and closing weeks of the crop the factory is almost entirely dependent upon estate cane. During the height of the crop the farmers are principally engaged in reaping and transporting their own cane so that the supply of labour for the estates is considerably reduced.

Towards the end of, and immediately after, crop, the farmers attend to the cultivation of their ratoon and plant canes. If the financial results of the crop have been good, the sale of their cane, and their ability to borrow from the estates or the shops, will render them largely independent of labouring on the estates. If the financial result of the crop is poor, the diminished proceeds from their cane, together with the increased difficulty of securing advances, will compel them to work more often on the estates. The supply of estate labour invariably diminishes towards the end of, and immediately after, crop, the extent of the reduction varying with the financial results of the crop.

Less attention is paid by the farmers to their cultivation than by the estates, and with the exception of the rice planting season, the supply of labour normally increases until the rice reaping season in November-December. During the first three weeks of December, the labourers, particularly West Indians, endeavour to earn good wages for the Christmas festivities, which decrease the supply of labour during the latter part of December.

In general, then, the supply of labour on the sugar estates is large at the commencement but tends to diminish during the height and towards the end of the crop season, and is greatly diminished immediately after crop. A slight improvement about July is followed by a decrease during August, the rice planting season. From that period the supply increases until November-December, when it again tends to diminish. In January the supply again increases. All the factors responsible for reducing the supply of labour at different periods, with the exception of the rice industry, vary in their effect with the prosperity of the year, so that the reduction in the supply of labour will be greatest during years of prosperity.

The demand for labour by the estates also fluctuates throughout the year. Transport difficulties, primarily, limit the manufacturing period to the dry season, and from the end of January to the beginning of June, effort is concentrated upon reaping the cane and the manufacture of sugar. Owing to the heavy capital cost of the factory*, and the fact that it can be used only four to five months each year, it is operated day and night, stopping only 24 hours during the week-end for adjustments, repairs and cleaning. Factory operating costs per ton of cane vary inversely with the quantity crushed daily (7), and deliveries are therefore kept as near as possible to the maximum capacity of the factory. Reaping, loading, carting and delivering estate cane to the mill involve a heavy demand for labour which is greatest at the commencement and end of the crop, because farmers are not reaping, and the whole supply of cane has to come from the estates.

Canes planted during the wet season, and those which are to be ratooned, require cultivation during the dry season. With the commencement of the rains the labour demands for weeding, draining, and moulding the earth around the canes, become heavy, and continue until, towards the end of the year, the canes have grown so thick that the fields are difficult to penetrate. Planting is undertaken chiefly during the wet season, and continues until November. The demand throughout the wet season is continuous, but not so heavy as during the crop season when the regular daily delivery of cane to the factory is essential. The demand for labour decreases from the end of November until the commencement of the crop season at the end of January. Attention during this period is principally directed to the young plant canes.

* Estimated locally at £20 to £25 per ton of sugar produced.

A variety of factors influence the seasonal supply of, and demand for, labour on the sugar estates and tend to produce a shortage of labour at some periods and a surplus at other periods. Briefly the shortage is most general during the cane reaping and rice planting seasons. At the commencement of the crop the supply of labour is above the average, but the demand for labour still more above the average. The estate demand is diminished as the canefarmers commence reaping, but the supply still remains generally inadequate. The estate demand increases still further towards the end of crop as the supply of farmers' cane diminishes. The shortage of labour during the crop period is reflected in the irregular delivery of cane to the factory and the neglect of plant and ratoon cane cultivation.

With the termination of the crop, the demand for labour, to rectify cultural omissions during the crop season, remains high, but the supply decreases still further. A definite improvement in supply normally takes place during July, though it tends to remain slightly below the average, but during August rice planting again occasions a shortage of labour which may persist for four or even six weeks. This shortage is not so serious as that of the crop season, as planting can be postponed till later in the wet season, and there is no urgent necessity for maintaining a uniform daily rate of planting.

After the termination of the rice planting season, the supply of labour steadily increases, and the main planting season is continued until the beginning of November. The tendency to reduce the number of ratoons has increased the labour demand for planting, but normally little difficulty is experienced in completing the planting programme which can, if necessary, be continued till late November. In November, December and January both the supply of, and demand for, labour diminish, but the principal difficulty is to find employment for all the available labour. A temporary shortage, rarely very serious, may be experienced during rice reaping.

The principal problem of the sugar industry is to reduce the demand for, or increase the supply of, labour, during the crop season, particularly in the early and latter parts, immediately after crop, and during the rice planting season. It would also be desirable to introduce measures whereby employment could profitably be increased during parts of November, December and January. Figure 4 shows the seasonal variation in the number of units of labour employed on a typical sugar estate. During the period February to October the supply of labour is the factor which is chiefly responsible for the fluctuations in numbers employed, while from October to January the demand for labour is the predominating factor. The standard deviation of the units of labour employed four-weekly is 14 per cent.*

* The four-weekly deviations are calculated from the averages of each year.

Table 22.—Showing number of sugar estates from which four-weekly records are received which experienced a shortage of labour.

Period Ending	Total.	No. Short.	Percentage Short.
28- 7-28 ..	17	6	35
25- 8-28 ..	17	10	59
22- 9-28 ..	17	5	29
20-10-28 ..	17	2	12
17-11-28 ..	17	4	23
15-12-28 ..	17	2	12
12- 1-29 ..	17	8	47
9- 2-29 ..	17	8	47
9- 3-29 ..	17	8	47
6- 4-29 ..	17	7	41
4- 5-29 ..	17	7	41
1- 6-29 ..	17	5	29
29- 6-29 ..	17	8	47

NOTE.—In both the sugar and cacao industries prices fell rapidly during the period under review. This has tended to relieve the labour situation on the estates during the latter periods, since canefarmers are planting less than last year, while peasant cacao cultivators cannot afford to attract labour from the estates.

V.—THE CACAO INDUSTRY.

Variations in the supply of labour for the cacao estates arise principally from the activities of peasant cacao cultivators, and other casual labour. The proportion of non-resident labour is therefore an important factor, and estates within a short distance of one another may vary greatly in this respect. The Montserrat district, and those of the Southern Range and Sangre Grande to a smaller extent, are areas of large estates with relatively few small-holders. The Northern Range contains large numbers of small-holders, so that the variations in the supply of labour are greatest in this area, and smallest in the Montserrat district. The small-holders cultivate small patches of cacao and food crops, so that their busiest periods are similar to those of the estates.

As in the sugar industry, the supply of labour is curtailed on those cacao estates within reasonable distance of rice areas. In the Northern Range and Sangre Grande districts, West Indian labourers predominate, and they, unlike the East Indians, do not often engage in rice cultivation. There is no extensive rice area in the Northern Range, and only 200 acres in St. Andrew (2). Extensive rice areas are some distance from the main cacao area of the Montserrat District, but some labourers migrate during the planting and reaping seasons. The cacao industry therefore suffers less than the sugar industry from the effects of rice planting.

The most laborious period in the cacao industry occurs during the crop season. Although some cacao is reaped during every month of the year,

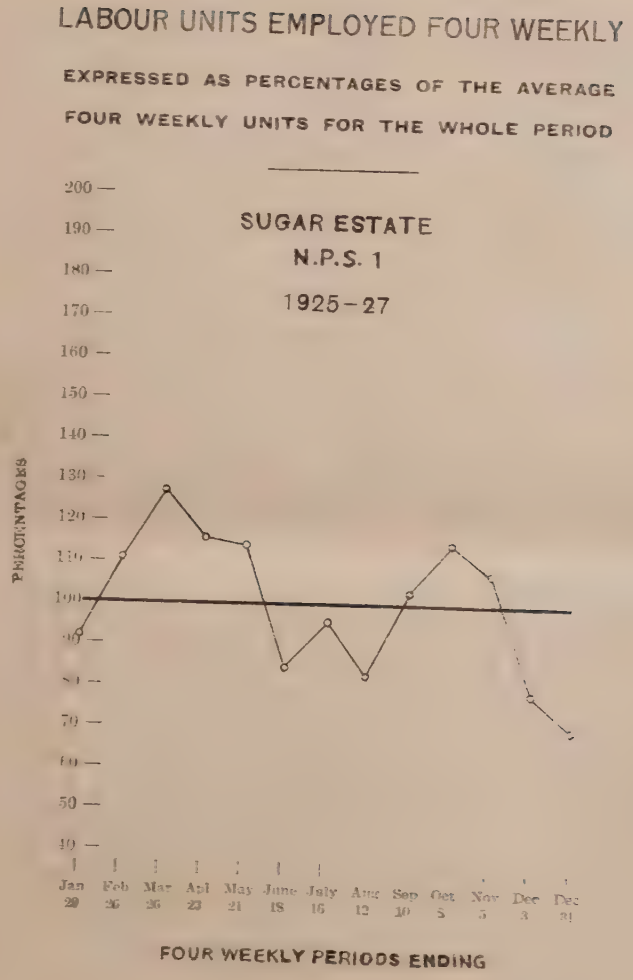

FIG. 4.

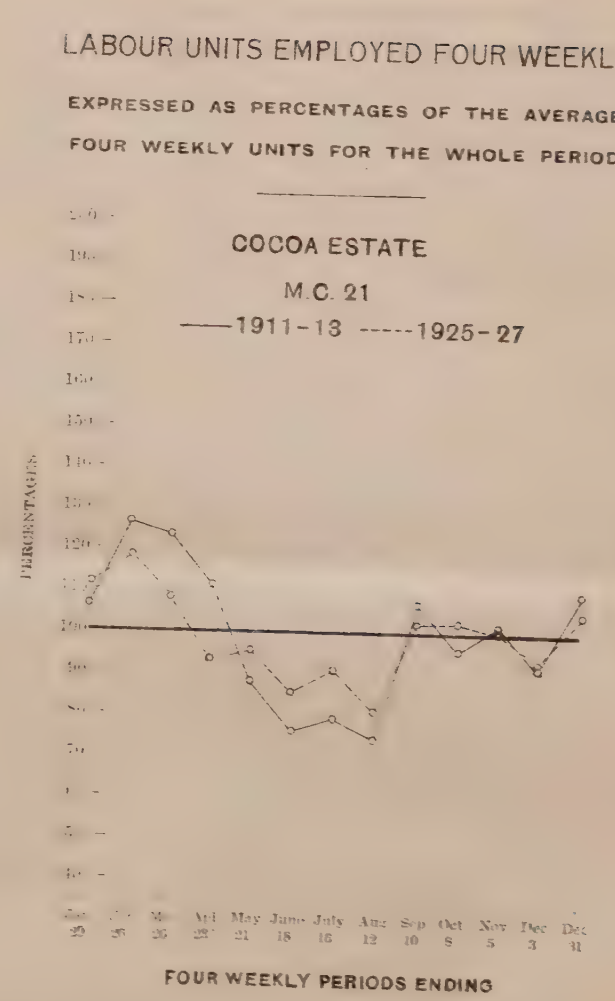

FIG. 5.—The irregularity of the seasonal employment was reduced during 1925-27 by providing more regular employment from May to August.

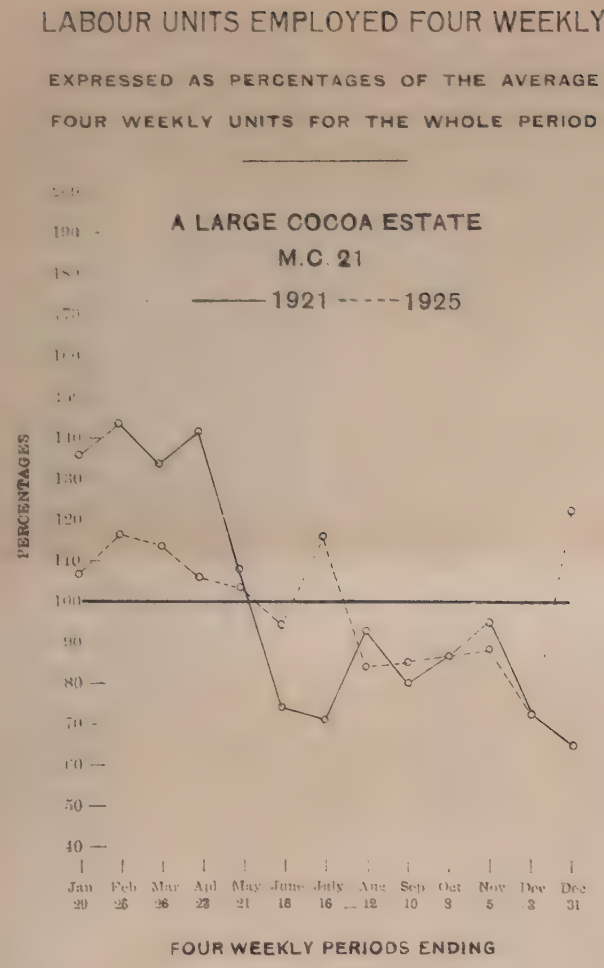

FIG. 6.—The sudden fall in prices in 1921 and the uncertain outlook led to an abrupt reduction of work after the main crop season. Owing to higher prices and better prospects in 1925, work was not seriously reduced until August. The main crop commenced early (December) during 1925-26.

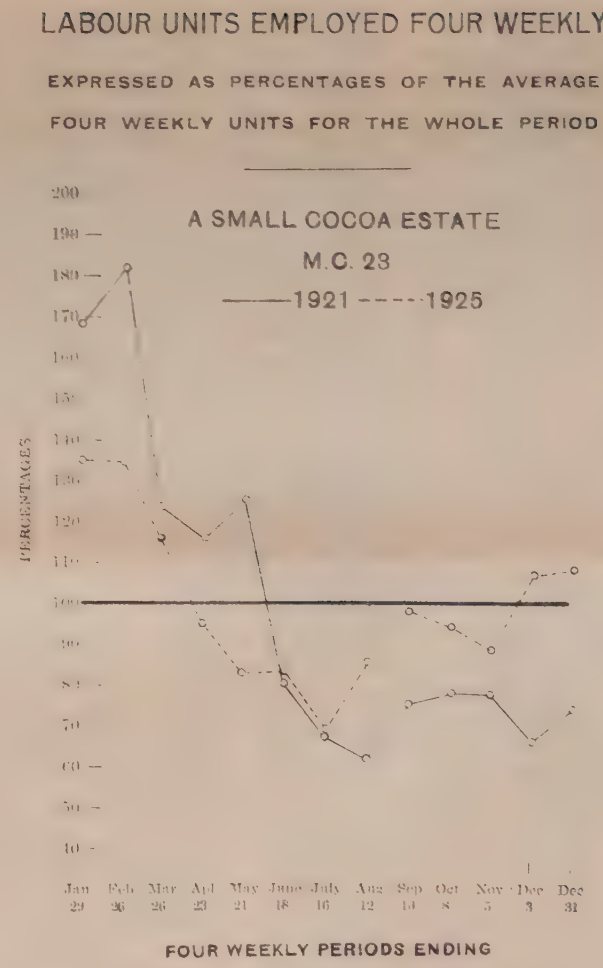

FIG. 7.—In 1921, owing to the heavy losses incurred, the work of the estate was largely confined to reaping. The improved outlook in 1925 led to greater expenditure on cultivation.

nearly 80 per cent. of the total is reaped during the six months December to May, the heaviest pickings occurring in January and February. The commencement, duration, and size of the main reaping season, vary considerably from year to year. The crop may be large or small, commence early or late, be concentrated within a short period or extended over a long period. Since reaping and manufacture absorb about one-third of the total labour units on a good estate, and considerably more on a badly cultivated estate, the nature of the particular cropping season is a matter of considerable importance. In general, the demand for labour during the period December to March is much above the average, particularly on the smaller and the badly cultivated estates.

The demand for labour falls rapidly after April as the main cropping season ends, but the decline is rendered less abrupt by pruning and trimming the trees which continues until about October. On most estates the trees are pruned about once in three years, a part of the estate being dealt with each year, but on others a much heavier pruning is given at longer intervals. Cleaning the drains commences in July or August with the beginning of the wet season. Cutlassing weeds is the chief occupation during the wet season. As a broad generalisation it may be said that the period from December to March is one of heavy pressure of work while during the remainder of the year, with the exception of August, the demand is below the average. The difference between these two periods is greater on the badly cultivated, and usually, smaller, estates, than on the well cultivated, and usually large, estates, owing to the diminished demand during the cultivation period. Thus on M.C.23, a small cacao estate, the standard deviation of the four-weekly units of labour during the three years 1925 to 1927 was 19 per cent., while on M.C.21, a large estate, it was only 10 per cent.*

All estates examined, irrespective of size or location, show a greater seasonal variation in demand for labour when prices are low than when prices are high, owing to the necessity of reducing expenditure on cultivation. Thus in 1921, a year of low prices ($10 per fanega), the standard deviations of M.C.23 and M.C.21, were 38 per cent., and 27 per cent., respectively†. In 1925, when prices had risen to $13, the standard deviations were reduced to 29 per cent., and 15 per cent. respectively. The average number of men-days employed four-weekly in 1925 was 352 on M.C.23, and 761 on M.C.21. It has similarly been found on all estates examined, that the seasonal fluctuations in units of labour employed during comparable periods were greater while the system of indentured immigration was in force than they are now. Thus during the three years 1911-13 the standard deviation of the units of labour employed four-weekly on a large estate (M.C.21.) was 19 per cent., while during 1925-27 it was only ten per cent.* Similarly on M.C. 23, a small estate, the standard deviations were 39 per cent. for 1911-13 and 19 per cent. for 1925-27. While the statistical evidence at present available is meagre, it suggests that estates are finding it necessary to provide more regular employment during the slack period, in order to retain the services of labourers for the busy season. There is, however, a limit to which regular employment can be offered in the wet season.

Since the fluctuations in work are similar for peasant cultivators, though more exaggerated, the supply of labour is reduced during the reaping season, when the estate demand is increased, while the supply is increased during the remainder of the year when the estate demand is diminished. The shortage of labour on the estates is consequently most general during the reaping season, while during the cultivation period there is normally a surplus of labour. The reduction in the supply of estate labour depends largely upon the ability of the peasants to remain independent of working on the estate, or their ability to hire labourers, so that the effect is greatest during a period of prosperity. On estates relying chiefly on resident labour, the busy period is met by more regular work, and longer hours of labour, whereas during the slack period the working days and amount of work offered are restricted.

Table 23.—Showing number of cacao estates from which four-weekly records are received which experienced a shortage of labour.*

Period Ending	Total.	No. Short.	Percentage Short.
28- 7-28 ..	34	25	74
25- 8-28 ..	34	22	65
22- 9-28 ..	34	11	32
20-10-28 ..	34	7	21
17-11-28 ..	34	9	26
15-12-28 ..	34	17	50
12- 1-29 ..	34	16	47
9- 2-29 ..	34	14	41
9- 3-29 ..	34	13	38
6- 4-29 ..	34	18	53
4- 5-29 ..	34	14	41
1- 6-29 ..	34	18	53
29- 6-29 ..	24	18	53

NOTE.—In both the sugar and cacao industries prices fell rapidly during the period under review. This has tended to relieve the labour situation on the estates during the latter periods, since cane farmers are planting less than last year, while peasant cacao cultivators cannot afford to attract labour from the estates.

The principal characteristic of cacao estates is, therefore, a period of heavy demand for labour succeeded by a period of slackness, the variations being caused principally by differences in the demand for labour.

* *See* Figure 5. † *See* Figures 6 and 7.

* *See* Figures 7 and 5.

On sugar estates it is desirable that measures should be introduced whereby the pressure during the reaping and rice planting seasons can be relieved, and the demand for labour during November to January increased. On cacao estates means of reducing the demand for labour from December to March, and of increasing it from April till November, would render the demand for labour more regular throughout the year.

Summary.

I.—Annual Variations.

In the sugar industry there is little variation from year to year in the total demand for labour, since sugar-cane necessitates continuous cultivation, and the wide financial resources of the sugar companies enable them to withstand occasional annual losses.

High prices for cane stimulate production by farmers and restrict the output of the estates, while low prices discourage canefarmers and enable the estates to increase their output.

Cacao estates are dominated by the mortgage system, and in a year of prosperity the activities of both estates and peasants expand, while during a depression both contract. The labour demands of other industries fluctuate sympathetically.

II.—Seasonal Fluctuations.

Estates largely dependent upon casual labour, generally show greater variation in seasonal employment than estates with a resident labouring population.

The rice industry seriously diminishes the supply of labour, particularly for the sugar estates, during August and, to a smaller extent, in November or December.

The East Indian marriage season also disturbs the regularity of the supply of labour in the sugar industry during the crop season.

Owing to the fact that canefarmers are busy reaping and planting cane during the crop season, when the estates make their greatest demands for labour, a shortage of labour often results. From November to January, however, there is normally a surplus of labour.

In the cacao industry, both estates and small peasant proprietors are very busy during the crop season, while during the remainder of the year the activities of both, slacken.

In both industries it is desirable that measures should be introduced to reduce the demand for labour during the crop season, and to increase it at other periods of the year.

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REVIEWS.

EASTERN AFRICA, TO-DAY AND TO-MORROW.

Compiled and edited by F. S. Joelson ; pub. East Africa. 7*s*. 6*d*. pp. 376 + xvii, 11 maps and 64 illustrations.

This book, we are informed in the preface, grew out of a desire to celebrate the tenth anniversary of the newspaper *East Africa*, and the Editor has adopted the admirable idea of bringing together in a single volume the opinions of the leading authorities on almost every East African question of importance, each writer not only giving a survey of the present position, but also a forecast of the developments he anticipates may take place during the next decade or so.

Even though most of the writers are averse to prophecy, the work is yet of great interest, for the very clear picture it gives of the present position in East Africa. The agricultural point of view is kept well to the front, for not only are special articles on the agriculture of Uganda, Tanganyika and Nyasaland, contributed by the respective Directors of Agriculture, but further information is given about coffee, sisal, sugar, essential oils and tobacco by writers qualified to deal with these crops. Moreover, there is an article on the Amani Research Station, contributed by Wm. Nowell, the Director, while other articles, of direct interest to the agriculturist, are The Future of Big Game, by Capt. Coldwell, the late Game Warden of Uganda and now in Kenya, and Anti-Tsetse Research by Swynnerton.

Everyone who is in any way interested in the development of East Africa, and Mr. Joelson makes this area stretch from the Sudan and Somaliland to Southern Rhodesia, will find matter of interest in this publication, which has the further merit of being inexpensive, well illustrated, and adequately provided with maps.

R. C. W.

THE AFRICAN WORLD ANNUAL 31ST EDITION.

London, 1934. Price 3*s*. 6*d*. Postage : Overseas 1*s*. 2*d*., Inland 9*d*.

This edition which is lavishly illustrated, presents a comprehensive history of African matters during the past year. Besides recording in detail the Duke of Kent's tour to South Africa, it includes many informative articles on the Union, Egypt, British East, West, Belgian and Portuguese Africa and a well-informed section on mining.

THE STORAGE OF AVOCADO PEARS.*

By C. W. Wardlaw and E. R. Leonard.

Introduction.

In preliminary studies relating to the storage behaviour of West Indian avocado pears (1), it was found that the majority of local "varieties" were unsuitable for refrigerated transport overseas because of their tendency to chill at temperatures insufficiently low to retard maturation processes. The fact that a few "varieties" were sufficiently cold-resistant, however, indicated that further storage trials might be undertaken with useful practical results. Accordingly, during the avocado season of 1934, a comprehensive series of storage experiments was again carried out, the results of which are summarised below. With a view to elucidating peculiarities in the physiological behaviour of this fruit during ripening, investigations into the nature of respiration, chilling, tolerance of gas-storage and relevant biochemical aspects have also been commenced.

General Observations.

Anticipating, for the sake of greater clarity, observations and conclusions substantiated in later sections, some general characteristics of West Indian avocado pears may be briefly mentioned at this point.

1. With very occasional exceptions (*e.g.*, the *Pollock* variety), West Indian avocados are of seedling origin and show a striking range in variation in a number of important characteristics:

(*a*) shape may vary from small sub-spherical fruits to elongated bottle-necked fruits of large size;

(*b*) colours include dark green, pale green, yellowish green, and purple;

(*c*) the skin may be thick or thin, waxy or dull, rugose or smooth, relatively soft in texture or distinctly woody;

(*d*) flesh colour varies from a medium yellow to pale greenish-white;

(*e*) leaving aside questions of palatability which are difficult to define, but which may range from an insipid, floury to a rich nutty flavour, the flesh may vary in the matter of oil-content, development of fibre and thickness;

(*f*) variations are also readily apparent in the size and shape of the stone, its proportion to the total weight of the fruit, and the nature of its insertion, *i.e.*, loose or adherent to the flesh.

2. During cold storage, even at relatively low temperatures, maturation processes slowly continue so that fruits ultimately become ripe and finally over-ripe. In the few varieties which are sufficiently cold-resistant or tolerant of low temperatures, such ripening apparently takes place in a more or less normal manner, the flesh at maturity being of good flavour and free from internal breakdown, discolouration or other obvious abnormalities. On the other hand, in the majority of varieties, *i.e.*, those which do not possess adequate cold resistance, maturation processes also continue but it is evident that the metabolic trend is abnormal. Thus although such fruits eventually become soft in cold storage, inspection of the flesh at once shows that chill effects have been induced. The range in genetical constitution outlined above is strikingly exemplified in the matter of cold-resistance: this extends from varieties subject to chilling after 15 days at 53°F to those which ripen normally during 40 days at 40°F.

3. A comparable though not necessarily parallel variation in response to gas-storage conditions has also been observed: this ranges from fruits which mature normally after treatment to atmospheres containing sub-normal oxygen or high carbon dioxide concentrations, to those in which pronounced pathological symptoms are induced by such treatments.

4. Considerable differences are also apparent in the rates of ripening of different varieties under controlled conditions and in their subsequent keeping quality.

5. Variations in genetical constitution are reflected in the resistance of different varieties to anthracnose and to other storage diseases: this ranges from fruits which are severely affected in the field prior to reaping to those in which little wastage develops even after prolonged storage. So far susceptibility to fungal pathogens has not been correlated with any particular type of rind.

6. In general, the collective genetical character of West Indian avocado pears and the impress of climate and environment are such that the behaviour of varieties in cold storage shows marked departures from the records obtained by investigators elsewhere.

Summary and Recommendations.

1. An account is given of further investigations into the cold storage behaviour of West Indian avocado pears, with a view to preparing the way for an export industry to Canadian and British markets.

2. West Indian avocado pears show a striking range in variation in colour, shape, size, texture of skin, proportion of stone to pulp, colour and fibre-content of pulp and in palatability. When fruits are placed in cold storage this genetic

* Extracted from Memoir No. 1, issued by the Low Temperature Research Station, Trinidad. Copies of this Memoir by C. W. Wardlaw and E. R. Leonard on "The Storage of Avocado Pears" may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I. Price 2*s*.

variability is further reflected in differences in keeping quality, susceptibility to fungal pathogens, rate of ripening and to tolerance of low temperatures.

3. In confirmation of earlier investigations, it was again found that a large majority of Trinidad varieties do not possess the keeping quality and are not sufficiently cold-resistant to be held for normal commercial periods (16 to 25 days) at 45°F. At this temperature such varieties are subject to chilling, with concomitant discolouration of the pulp and in some instances of the skin. On the other hand, if these varieties are kept at higher temperatures, *i.e.*, above the chilling temperature, consignments are liable to become over-ripe before the normal and relatively brief storage period has elapsed. It follows, therefore, that in developing avocado orchards and in organising an export industry, only those varieties should be used which are known to possess adequate cold resistance. In practice, this means that the majority of avocado types scattered throughout the West Indies, though excellent for local consumption, should not be used for export. This leaves a relatively small minority possessing the low temperature resistance and keeping qualities necessary for establishing West Indian fruit on distant markets. Thus, from current investigations, *it is recommended that some or all of six varieties should be used during the coming avocado season for trial shipments, the fruits to be picked full grown, but quite firm, or in colouring varieties, full-grown but green, suitably packed and protected in slatted crates and transported at a steady temperature of* 45°F. *These stocks should also be used for propagating purposes. Casual shipments of varieties not adequately tested for keeping quality and low temperature resistance should be discontinued: not only are such consignments almost certain to arrive on distant markets in bad condition and thereby create prejudice against West Indian Produce, but repeated failures will also result in the discouragement locally of a possible export industry.*

4. The phenomenon of chilling in avocado pears presents points of considerable scientific interest. It may be manifested in different ways in different varieties. A notable feature of chilling at the storage temperatures used is that complete killing of the internal tissues as a result of over-refrigeration does not take place. On the contrary, maturation processes continue but follow an abnormal biochemical trend, finally culminating in the production of a soft but darkened pulp of poor flavour. It has been shown that the onset of chilling is closely associated with ripening processes, when the fruit, which is then passing through a critical stage, is apparently more subject to modification under the impact of external factors.

5. As anticipated in earlier researches, certain varieties lend themselves to preservation by gas-storage methods. Here again, however, a considerable range in variation is apparent, some varieties being intolerant of high concentrations of CO_2 or low concentrations of O_2. In extension of this aspect of preservation, fruits were smeared with different substances to determine if ripening could be delayed without injury to the fruit. The results obtained show that the application of relatively impermeable substances definitely delays ripening. Further search for a suitable coating is, however, necessary, as those so far tested limit gaseous interchange to an extent inimical to normal ripening.

In conclusion the writers wish to express their thanks to the Trinidad Department of Agriculture and to members of the planting community for their assistance in providing supplies of fruit.

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(1) Wardlaw, C. W.—Preliminary Observations on the Storage of Avocado Pears. *Tropical Agriculture*, Vol. XI, No. 2, pp. 27-35, 1934.

VERNALISATION.

Since the publication of Bulletin No. 9 on vernalisation by the Herbage Bureau, Aberystwyth, research on the subject has been proceeding rapidly in the U.S.S.R. The many conflicting statements that have appeared in the scientific and popular literature, however, have made it desirable that an authoritative account of the subject should be given, and the Bureau, with the collaboration of Prof. N. A. Maximov, of the Institute of Grain Husbandry, Saratov, U.S.S.R., has issued a further publication, "The Theoretical Significance of Vernalisation" as *Bulletin No.* 16 in the Herbage Publication Series (Aberystwyth: *Imp. Bur. Plant Genetics*, 2*s.* 6*d.*). Since the discovery that by subjecting partially soaked seed to low temperatures, winter varieties of cereals could acquire the properties of spring varieties, that is, yield the same summer, the investigations have been extended to other types of plants. In the case of soy bean and cotton, vernalisation is effected by exposure of soaked seed to sufficiently high temperatures, after which fruit is formed successfully, even if subsequent temperatures would normally be too low. On the theoretical side, Lysenko's views are discussed in full, the most important of which seems to be that growth and development are essentially different phenomena. The plant, although in an apparently dormant condition, may be undergoing transitional developmental processes which can be profoundly affected by external conditions. Changes in the nature of the plant's composition are also brought about by vernalisation, both the colloidal properties of the protoplasm and the staining reaction of the embryonic tissue being altered after treatment. The first idea, that vernalisation actually accelerated plant development, is now regarded as needing modification. The truer interpretation seems to be that part of the growth period, which normally takes place in the field, can be transferred back to the early germination stages. The question as to whether or not vernalisation is an irreversible process is still a debatable point.—(*Nature*, Vol. 135, No. 3407, 1935, p. 273.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Invert Sugar from the Cashew 'Apple'.

In India the cashew, *Anacardium occidentale*, L., is largely cultivated for the nut, and the curious fleshy swelling of the axis beneath the nut is discarded. M. Srinivasan, of the Department of Biochemistry, Indian Institute of Science, has been exploring the possibility of utilising this fleshy 'apple' (*J. Indian Inst. Sci.*, 17A. Part 7.). Alcohol could be obtained from its juice by fermentation, but the cost involved would not warrant large-scale production; on the other hand, the juice contains about 7 per cent. invert sugar on the fresh weight of the apple and may easily find a use as a syrup. Pigments present in the juice render more simple its correct neutralisation by lime, and at neutralisation there is complete precipitation of albuminoids and tannins so that filtration is easy. The lime has then to be removed (as carbonate, sulphite or phosphate), before the juice is concentrated, when it yields a clear red syrup for which there may well be considerable demand, as invert sugar is in great use by confectioners. It may also serve as a useful source of laevulose, the sugar to which diabetic patients show so much tolerance.—(*Nature*, Vol. CXXXIV, No. 3397, p. 903, 1934.)

* * *

Meteorology of the West Indies.

The "Handbuch der Klimatologie" of W. Köppen and R. Geiger when complete will be in five volumes (Berlin, Gebrüder Borntraeger, 1934). A number of different parts of this work have already appeared as each has been completed, of which the most recent (Band 2, Teil 1) is entitled "Climatology of the West Indies". The text of this was written in 1927 by the late Prof. R. de C. Ward, formerly professor of climatology at Harvard University, who compiled his account largely on the basis of summaries by W. W. Reed that had appeared a year earlier in the *Monthly Weather Review*. Prof. C. F. Brooks, director of Blue Hill Observatory, with the help of Miss E. M. Fitton and others, extended the tables and summaries; finally Prof. Ward revised the whole work shortly before his death. European meteorologists hear of these regions chiefly in connexion with tropical hurricanes, but the introductory part of this work shows that there are other aspects of their meteorology of equal interest. The West Indies show great uniformity of temperature, such as is to be expected of islands of which the greater number lie just within the tropics, but those nearest to the mainland of Central America feel to some extent the effect of the winter cold waves of North America, resulting from southward incursions of polar air; the more easterly and southerly members of the group escape these effects and have a correspondingly small annual range (2° C. only at Barbados). While temperature changes are unexciting and the simple régime of the north-east trade winds is only rarely disturbed by a hurricane, rainfall shows great variability both in the amount experienced in different years at one place and in the normal amount received at places no great distance apart. At Silver Hill, Jamaica, the total fall in three days, 5th to 7th November, 1909, was 2,159 mm. (85 in.) and in the seven days to 11th November, it was 3,428 mm. (135 in.). In the same island, two places only 30 miles apart and differing in elevation by only 189 metres have normal annual totals of 735 and 5,638 mm. respectively. The numerous detailed tables in this work repay study, for example, Table 12, which shows thunderstorm frequency. Some of the islands have only about the same number as the English midlands, but at Port au Prince (Haiti) the annual frequency is about 107.—(*Nature*, Vol. CXXXIV, No. 3,398, pp. 940-41, 1934.)

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The Progress of Applied Chemistry.

The Nigerian Department of Agriculture made most important contributions to the problem of the maintenance of soil fertility by green manuring under tropical conditions with seasonal rainfall. Where two crops are grown each year, fertility can be maintained if one is leguminous and one exhaustive, provided that by careful farming good cover crops are obtained, the soil is protected from exposure to leaching and erosion, and the straw and haulms are not totally removed from the land. It made little or no difference whether the green manures were buried while young or after seeding, whether they were green or desiccated for three months, or whether the tops were burned, provided that the ashes were retained. Burning was not only the most convenient, but actually the best method of disposing of the crop. By careful work along these lines it has been demonstrated that under the conditions of Southern Nigeria soil fertility can be maintained under a stable system of farming based on green manuring.—(*Annual Reports of the Soc. of Chem. Indus.*, Vol. XIX, 1934, p. 552.)

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Soil Survey in Puerto Rico.

A sum of fifteen thousand dollars ($15,000) has been allotted from sugar-processing tax funds and approved by President Roosevelt for the purpose of conducting a soil survey of Puerto Rico. The Bureau of Chemistry and Soils Division of the Department of Agriculture of the United States will carry out the survey. Its prosecution is regarded as a fundamental need in the economic rehabilitation of Puerto Rico.—(*Facts about Sugar*, Vol. 30. No. 1, p. 15. 1935.)

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Determination of Potash in Juice and Molasses.—*Vivian Olivier.*

Recently a convenient and rapid method for the determination of P_2O_5 in juices was described*, and now an equally practical and expeditious process is given for K_2O. It is precipitated as potassium sodium cobalti-nitrite, separated by centrifuging, and determined volumetrically. This procedure, compared with the platino-chloride method, is quick and economical, besides being sufficiently rapid for general purposes. Many modifications of it have been published, but that which now follows should be found to be particularly well adapted for routine work.

First, the juice or molasses (using a 5 per cent. solution) is clarified by treating 100 c.c. with sufficient lime to give a pink colour with phenol-phthalein, boiling for a few minutes, cooling, restoring the volume with distilled water, mixing and filtering. Then 3 to 5 c.c. of the nitrate are mixed in a conical centrifugal tube of about 15 c.c. capacity, with about 5 c.c. of the cobalti-nitrite reagent.

(This reagent is composed of two solutions: A and B. Solution A contains 50 grms. of cobalt nitrate, 25 c.c. of glacial acetic acid, and 100 c.c. of water; and Solution B 120 grms. of sodium nitrite in 180 c.c. of water. Just before use, 2 c.c. of Solution A are mixed with 10 c.c. of Solution B.)

After allowing the contents of the tube to stand for half-an-hour, the mixture is centrifuged for 2 min. at 200 r.p.m., after which the clear liquid is decanted carefully; 10 c.c. of water are mixed with the precipitate, and the tube again spun for 2 min., which washing process is repeated in all three times. It is desirable that the temperature should not be above 20°C., otherwise a bath at about 10°C. should be used to cool the liquid.

Now place 20 to 35 c.c. of N/20 potassium permanganate solution (*a*) in a beaker with 100 c.c. of water†, cover with a clock-glass, bring to boiling; acidify with 10 c.c. of dilute sulphuric acid (1:5) and boil for a minute. Next, using a very hot jet of distilled water, wash the cobalti-nitrite precipitate into the beaker, mix, and allow to stand for about 8 min., after which add a determined volume of N/20 oxalic acid (*b*) to dissolve the brown precipitate formed,‡ sufficient of the N/20 $KMnO_4$ solution being finally added to restore the colour to a pale but permanent pink colour (*c*).

A blank (*d*) is done with the distilled water and 5 c.c. of the cobalti-nitrite solution under exactly the same conditions (usually about 0.5 c.c. of the $KMnO_4$ solution are required). Then $a+b-c-d=x$ (c.c. of N/20 $KMnO_4$), so that by multiplying X by one of the factors below (which vary according to the c.c. of the sample taken, and according also to the product analysed), the grms. of K_2O per 100 c.c. of the juice or of the 5 per cent. molasses solution, are obtained.

Sample taken in c.c.	*Factors for the Juice.*	*Factors for 5 per cent molasses solution.*
3	0.01383	0.27667
4	0.01038	0.20750
5	0.00830	0.16600

Results obtained with this method show a close agreement with the gravimetric platino-chloride process. In juices the K_2O was found by the author to average 0.120 to 0.129 per 100 c.c., and in molasses 3.68 to 3.76 per cent. by weight of actual molasses. It is remarked that the K_2O may vary somewhat in juices, and is well worth determining at intervals, seeing that it is a true indication of the "richness" of the soil. — (*Inter. Sugar Journal*, Vol. XXXVII, No. 434, 1935, pp. 75-76.)

* International Sugar Journal, 1934, pp. 244-245.

† N/20 $KMnO_4$ contains 1.5805 grm. of the salt per litre.

‡ The N/20 oxalic acid contains 3.1512 and 50 c.c. of sulphuric acid per litre.

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Notes on Low Grade Massecuites.—*D. M. Glick.*

To determine whether or not the use of heating coils in the mixers had any appreciable effect on the purity of the molasses, samples of massecuites were taken from each crystallizer just before discharging to the mixer, and a comparison was made between the molasses so obtained and molasses from the same massecuite from the centrifugals. The average difference in purity was 0.29°; the saturation temperatures, as determined by the saturoscope, varied between 106° and 110°F. On the other hand, the addition of water to the massecuites to reduce the viscosity (instead of by heating) increased the purity by 0.76°. It seems impossible to add even small amounts of water without causing a notable increase in purity, whereas temperatures in the mixers may be raised from 6° to 10°F. above the point determined on the saturoscope without an apparent rise in purity.—(*Facts About Sugar*, Vol. XXIX, No. 12, 1934, pp. 447.)

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Syrup Manufacture—*S. J. Saint.*

In syrup manufacture, the principal problems are the elimination of mud and the prevention of crystallization in the final product. In the small plants, which are not equipped with any chemical laboratory, it has been found that both of these problems can be solved with the aid of pH control. A pH of 6.6 to 7.0 in the clarified juice eliminates much of the sediment in the settlers, and a pH of 4.6 to 4.8 in the juice after clarification results in sufficient inversion of sucrose to prevent after-crystallization. — (*Inter. Sugar Journal*, Vol. XXXVII, No. 434, 1935, pp. 77.)

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		Preferential.	
	s.	d.	s.	d.
28th February	4	5¼	8	2¼
7th March	4	6	8	3
14th March	4	6¾	8	4½
21st March	4	8¾	8	5¼
28th March	4	9	8	6¾
4th April	4	11¼	8	8¼
11th April	5	0	8	9
(*12th April*, 1934)	5	3	9	4½

The more buoyant tone displayed recently in the market has been reflected in the modest advances made in raw values. First hand Raw Sugar holders have been maintaining a firm attitude and are asking prices somewhat higher than parities ruling in the United Kingdom. The market has generally presented an appearance of greater stability while prices appear to have been unaffected by extraneous factors such as exchange fluctuations and political events in Europe.

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COCOA.—On account of uncertainty in world affairs cocoa like most other commodities is weak, and prices since our last have been steadily going down. At the moment the local price of Plantation cocoa is $5.50 a fanega and from latest advices from London Accra is quoted at 22*s.* 3*d.* c.i.f.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

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RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	pence per lb.
27th February	6 1-4
6th March	6 1-16
13th March	5 15-16
20th March	5 9-16
27th March	5 7-8
3rd April	5 5-8
10th April	5 9-16
(*11th April*, 1934)	5 19-32

Since our last report the market has become weaker and prices have been sagging consistently. The news that the International Committee had decided to leave the exportable percentage at 75 per cent. for the April-June quarter and to reduce it to 70 per cent. for the July-September quarter was mildly disappointing. Increased nervousness has been caused also by fluctuations in the exchange, the break in cotton prices and by the news that some American tyre factories had decided to work shorter time. American consumption for February is estimated at 43,187 tons.

BANANAS.—There is a slight improvement in the demand. Jamaicas are unchanged at £18 5*s.* per ton delivered London and £18 nearest station Provinces. Brazilians continue to be quoted at £18 nearest station. The imports in bunches into the United Kingdom for the fortnight ended 23rd February were as follows: Jamaica, 343,721; Trinidad, 1,902; Gold Coast, 541; Canary Islands, 2,672; Columbia, 31,850; Brazil, 65,873; Nigeria 24,324.—(*West India Committee Circular*, 14th March.)

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COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian F.G.F. Sakel.*
22nd February	7.10	8.86
1st March	7.09	8.81
8th March	7.10	8.84
15th March	6.59	8.40
22nd March	6.30	8.55
29th March	6.41	—
5th April	6.36	—
12th April	6.54	—
(*13th April*, 1934)	6.35	8.61

There has been a slump in prices due mainly to heavy liquidations by long interests in New York which are distrusting the ability of the Washington Government to maintain prices. It would now appear also that the advances to growers of 12 cents per lb. under the loan plan of the Government were fixed at too high a level. A few retail sales of West Indian Sea Island are reported at 15 to 15½ pence.

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COFFEE.—The market has been quiet. Good Kenya and best qualities Costa Rica, have, however, been in demand, the latter realising 102*s.* for bold sizes London cleaned.

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LIME PRODUCTS.—*Lime Oil.*—An arrival of about 100 lb. of Handpressed has sold at 32*s.* 6*d.* Sellers now ask 35*s.* c.i.f. for shipment. Distilled is firm. The new selling arrangement has resulted in considerable movement of stock from London and New York dealers' hands. Sales have been made for shipment from origin at 22*s.* 6*d.* c.i.f., and although the demand appears to be temporarily satisfied, the new price level is said to be firmly established. This augurs well for the new crop. *Lime Juice.* — Concentrated is unchanged with buyers at £4 15*s.* There is rather more enquiry for Raw with prices unchanged at 2*s.* to 2*s.* 6*d.* per gallon for Jamaica according to quality.—(*West India Committee Circular*, 14th March.)